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IMPACT OF THE MACROECONOMIC POLICIES BASED ON THE COMPUTABLE GENERAL EQUILIBRIUM MODEL (THE CASE OF THE REPUBLIC OF MOLDOVA)

521.01. ECONOMIC THEORY AND ECONOMIC POLICIES

Summary of the doctoral thesis in economics

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The public defense will take place on 29.12.21, at 14.00, during the meeting of the Commission for public defense of the doctoral thesis, at the Academy of Economic Studies of Moldova, mun. Chisinau, 59, G. Banulescu-Bodoni str., MD-2005, office Senat. The doctoral thesis and the abstract can be consulted at the Scientific Library of the Academy of Economic Studies of Moldova and on the website of ANACEC (www.cnaa.md).

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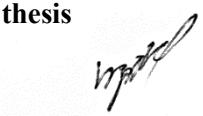
Professor, Academician  Grigore Belostecinic

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CONCEPTUAL GUIDELINES OF THE RESEARCH

The relevance and importance of the research. The impact of macroeconomic policies on the general economic equilibrium (GEE) is constantly attracting the attention of economists. GEE-based analysis is indispensable in case of combined shocks, cascading shocks, or shocks with differentiated impact on economic sectors. The ex-ante quantitative assessment of the impact of macroeconomic policies is of utmost relevance for the quality of government in the Republic of Moldova (Iliadi & Caraganciu, 2006). Economic and social cost of policy errors can be high. Besides knowing the impact on the main macro-indicators, it is equally important to understand the distributive impact of shocks, including, in regional perspective which is usually less considered in practical analysis of macroeconomic policies. Computable General Equilibrium (CGE) models respond to these priorities and offer quantitative results that are useful for policy purposes.

Degree of study of the problem. Macroeconomic policies and their repercussions on economic equilibrium is an emerging subject in the national research. Baurciulu A. studied the dimension of financial balance at macroeconomic level (Baurciulu, 2007), and Dodon S. – approached the budget deficit as a precondition for achieving economic growth (Dodon, 2014). Remarkable contributions in the GEE analysis based on CGE models were made by Elvira Naval. In particular, the researcher proposed a compact CGE model for assessing the evolution of the national economy under various scenarios (Naval, 2018). In 1999, a CGE model was used to evaluate the trade policy options of the Republic of Moldova (Alanoca, Hristev, Muntean, Naval, & Savenko, 1999).

The general equilibrium has a notable presence in economic research in other countries in the region. Romanian economists treat the subject in monographic studies (Dumitrescu, 2002), in doctoral theses of theoretical (Opreana, 2012) or applied character (Mohora, 2006). Models have been developed to assess the impact of Romania's accession to the EU (Mohora, 2006) or the transition to the green economy (E3M LAB, 2015).

CGE models are also widely used in Ukraine. Concrete topics studied based on CGE models include the distributional effects of trade liberalization between Ukraine and the European Union (Movchan & Shportyuk, 2013), the macroeconomic impact of Ukraine's accession to the WTO (Kosse, 2010) or the impact of pensions system reform (Lisenkova, 2011).

In the Russian Federation, a CGE model has been used to study the interaction of market structures with carbon taxation policies (Orlov & Grethe, 2012). Another example of complex research conducted in the Russian Federation is the use of a dynamic regional CGE model with overlapping generations to study the impact on the generations welfare of reduced budget revenues from hydrocarbon export taxation combined with an increased minimum retirement age (Зубарев , Казакова, & Нестерова, 2018).

Outstanding researches based on CGE models have been done in Australia, USA, New Zealand, Canada, France. We would like to mention the suite of CGE models developed by the International Food Policy Research Institute (IFPRI), with the standard CGE model of this institution (Lofgren, Lee Harris, & Robinson, 2002) guiding us in our own research. The CGE field is prolific in terms of topics and approaches, mathematical structures and solution algorithms. The range of applications is wide, including foreign trade, public finance, agriculture, transport and urban economy, rural development, migration, climate change - to name just the most common areas of application.

The aim of our research is to study the impact of macroeconomic policies, especially fiscal, trade and structural policies, on the general economic equilibrium in the Republic of Moldova based on a CGE model with a high level of detail. Taking into account the stated goal, the objectives of our research are:

- Carrying out an overview of main approaches in the general equilibrium theory (GET) and in its operationalization;
- Reviewing the types, characteristics, limits and advantages of different CGE models;
- Studying the approaches used in different CGEs for modeling different components of the national economic system;
- Compiling an updated Social Accounting Matrix (SAM) for the Republic of Moldova with regional disaggregation;
- Using internationally recognized models for synthesizing a CGE with geographical resolution (REMMO - Regional Economic Model of Moldova);
- Calibrating REMMO based on SAM and estimating other parameters econometrically;
- Defining relevant policy shock scenarios for the Republic of Moldova;
- Simulating policy scenarios based on REMMO, evaluating the impact of policies on the general economic equilibrium and interpreting theoretically the simulation results;
- Conducting an analysis of sensitivity of results to the factor market closure rules.

The research hypotheses in the thesis are complex and include the following:

- Available statistical data provide a sufficient basis for compiling a macro-SAM for the Republic of Moldova compatible with the System of National Accounts (SNA);
- Using mathematical optimization methods, it could be possible to update the Input-Output Table (IOT) and compile a more detailed SAM;
- Even with limited data, a reasonably high degree of specification of regional economic flows in the CGE can be achieved;
- Relatively simple additions to some CGE-standard would allow the synthesis of a model adapted to the Moldovan economy - REMMO

(Regional Economic Model for Moldova), for modeling indirect taxes and subsidies, budgetary components at administrative levels, the rest of the world by on several trade regions and recursive dynamics;

- The available time series can be used to robustly estimate REMMO elasticity parameters at a SAM-compatible disaggregation level;
- Based on REMMO, the impact of policies can be analyzed, including: increasing VAT on agricultural products, liberalizing trade with China and reducing transaction costs;
- In case of fiscal policy, the hypothesis is that the VAT increase will involve differentiated increase of revenues at budgetary levels and will reduce the consumers welfare;
- For the liberalization of trade with China, the hypothesis is that the reduction by the Republic of Moldova of its customs tariffs will be followed by compression of economic activity, and the reduction by China of its own tariffs - by substantial increase of Moldovan exports;
- For the scenario of reducing transaction costs, the hypothesis is that the production capacities frontier will be expanded and that, from a distributive point of view, all regions of the country will benefit from a uniform increase in welfare.

The research methodology in this paper is based on GET. A wide range of **methods** and **techniques** were used in the thesis. The evolution of the theoretical framework of general equilibrium is followed based on the method of *historical analysis* and *synthesis*. *Mathematical modeling* is the main method used to compile REMMOs by completing / extending existing standard models. For the elaboration of SAM, *methods of economic statistics* are widely applied. A *numerical method* of information entropy minimization was applied for compiling the IOT, the regional accounts and for balancing the SAM. Based on the final SAM, REMMO was parameterized using the *calibration method*. *Time-series econometric methods* were applied to estimate some of the REMMO's elasticity parameters and some cells in the SAM. A specific tool used in the paper is *computer programming*, with the CGE implemented in the specialized programming language GAMS.

The novelty and scientific originality of the paper lies in the following:

- Theoretical and practical research on the impact of macroeconomic policy shocks on the general economic equilibrium is deepened and detailed, both from the perspective of the impact on the main macroeconomic and sectoral indicators and from the perspective of the distributive impact of shocks, including in regional perspective.
- A mathematical optimization solution is applied for updating IOT and for compiling regional production and operating accounts, given limited data on the structure of inter-branch flows.
- A many-to-one-to-many approach to integrating the regional dimension into the general economic equilibrium model is tested.

- A new approach is proposed in modeling the decision-making and policy framework, the government sector being disaggregated by four levels corresponding to the simulated budgetary system components (central budget, budgets of administrative-territorial units, state social insurance budget and mandatory health insurance funds).
- A very high level of detail of the Social Accounting Matrix (302 x 302) is reached, which is a unique result for the Republic of Moldova.
- The applicability of econometric methods for determining the coefficients of the CES function and the CET function is evaluated based on the time series aggregated at a level compatible with the classification adopted in SAM / REMMO.
- The results of the impact simulation of some policies relevant for the development agenda of the Republic of Moldova are interpreted in the context of GET.

The important scientific problem solved in the thesis consists in the complex evaluation of the quantitative and distributive impact of the fiscal, trade and structural policies on the national economy, the theoretical interpretation of the results and the analysis of the risks / benefits of the policies**.**

Approval of scientific results. The theoretical results are reflected in: 2 articles (2021) in the accredited journal "Economica" (category B, DOAJ database); 1 article (2021) in the accredited journal "Economics and Sociology" (category B +) and 3 materials in the proceedings of international scientific conferences (2016-2021). The practical application of the results was made in research applied to the World Bank (2016), the Ministry of Finance (2018) and the Ministry of Economy and Infrastructure (2020). Results were used in 2017 to conduct training on use of CGE fiscal models for the staff of the Ministry of Finance of the Republic of Moldova. An innovative approach applied by the author is the merger of the CGE-base analysis with the system of National Transfer Accounts and thus highlighting the impact of COVID-19 on women and men by ages in the Republic of Moldova.

Summary of thesis chapters. The paper consists of: annotations in Romanian, English and Russian, introduction, three key chapters and one of conclusions and recommendations, bibliography (116 sources), 21 annexes with the main results. The thesis contains 148 pages of basic text (up to Bibliography), 14 figures and 39 tables. The obtained results were published in 6 scientific papers.

Keywords: computable general equilibrium model, social accounting matrix, Republic of Moldova, macroeconomic policies, fiscal policies, trade policies, structural policies, impact assessment, national accounts system, regional economy.

THESIS CONTENT

Chapter 1 of the paper - **The theoretical-methodological framework of general economic equilibrium** - presents the conceptual basis of general equilibrium theory (GET). The author discusses the historical roots of GET and how it has influenced the emergence and evolution of CGE models.

Having a solid theoretical foundation, CGE models have the ability to assess the ex-ante impact of shocks on the entire economy, both in macroeconomic and redistributive terms (Böhringer, Rutherford, & Wiegard, 2003). Models in this class provide decision-makers with concrete quantitative benchmarks on the impact of future policies on economic equilibrium. From our point of view, these are the key advantages that explain the rapid increase in the number of practical uses of these models in recent decades.

The development and use of a CGE in policy analysis involve a large body of data and significant analytical effort. One of the heaviest criticisms of the CGE is the opaque nature of these models and the fact that the results are often difficult to understand. The development of computing technology and the increasing availability of open source data substantially reduce the costs and efforts required to compile and use these models.

The contemporary economic literature contains a broad typology, with models differing by mathematical structure, the way of introducing the dynamics in the model, the geographical resolution and other criteria. Together, they offer a wide range of approaches and solutions that make these models flexible and suitable for a large number of applications and extensions, from purely economic analysis to integrated cross-disciplinary analysis, touching on topics such as the impact of emigration or climate change.

Despite the conceptual diversity, all CGE models are ultimately based on the GET, which has been formulated due to contributions of Leon Walras, Vilfredo Pareto, Karl Gustav Cassel, Irving Fisher, Vasiliy Leontief, John von Neuman, Kennet Arrow, Gerard Debreu and others. GET sets out the conditions for a general equilibrium and identifies the connections between that equilibrium and economic efficiency. Although the existence of equilibrium can be demonstrated mathematically, the uniqueness and stability of equilibrium involve more restrictive conditions regarding consumption functions. Despite these limitations, GET resisted criticism and, beyond remaining a robust theoretical construction, has had important ideological implications. In particular, GET proves that, in terms of efficiency, the market economy system is superior to other systems. However, GET does not provide answers that would satisfy the principle of social justice and other ethical concerns.

CGE models differ substantially as theoretical framework from econometric models. Being parameterized, multisectoral mathematical models - in the sense of economic activities, goods, consumers, factors of production, etc. - these are, for the most part, macro models, but with a solid microeconomic foundation. These

features advantageously differentiate CGE models from other theoretically agnostic models.

As practical implementation, CGE models are based on systems of equations and inequalities that model the essential features of an economic system. Standard models assume the principle of perfect functioning of markets, which allows simple modeling of the interactions between markets and prices at different stages of the economic cycle or technological process. At the same time, modern models recognize the imperfect nature of the substitution between imported and local goods (Armington hypothesis) and the limited technological transformation between goods for local and export markets. The practice of modeling accumulated over the last decades allows the simulation of nested production and utility functions, definition of complex rules that guide the decisions of economic agents, etc. At the same time, we noticed in the literature that the simplest approach for introducing dynamics in the model is to run a static model in a recursive manner, so that the evolution of the economy is determined as a series of static equilibria (dynamically-recursive CGE models).

CGE parameterization involves the compilation of a Social Accounting Matrix (SAM) that must closely represent the economic system. A prior assumption of the SAM is that the system is in equilibrium in the reference year. This hypothesis is an essential one, because it justifies the use of SAM for the calibration of structural parameters, but the given hypothesis cannot be verified in practice, but only postulated on the basis of observations and economic logic. SAM can provide any level of detail, depending on the purposes of the analysis and the available data. Thus, we conclude that in terms of theoretical substantiation, practical implementation and the range of quantitative results provided, CGE models are some of the most appropriate tools for assessing the impact of decision shocks and programming policies for any planning horizon.

In Chapter 2 of the thesis - **Compiling the CGE model for the national economy** - the author developed the data set needed to run the model, proposed a mathematical specification that extends a some of the standard CGE models used as reference for the REMMO model and determined structural and elasticity parameters.

The research showed that statistical data in the Republic of Moldova can be used to develop a social accounting matrix of high quality. The elaboration of SAM involved a series of iterative processes, in order to ensure the compatibility with the macro-indicators from the NSA.

The author noted the lack of important indicators and sources needed to compile a detailed SAM, such as an updated IOT. Without IOT, it is impossible to determine inter-industrial economic flows. By combining the methods of economic statistics with those of mathematical optimization (Lee & Su, 2014), the author has compiled an IOT at a satisfactory level of detail and of quality and which satisfies the constraints imposed by the data in the NSA. The method of minimizing the information entropy used for recovering the missing data ensures that structurally

the updated IOT is the most likely version for 2019. IOT quadrant 1 is shown in Table 0.1, quadrants 2 and 3 in Table 0.2 and, respectively, Table 0.3.

One problem is related to the fact that in the process of updating the IOT, an IOT from 2014 was used as benchmark, and in that IOT there were already certain distortions and some of these problems migrated to the IOT updated for 2019.

The results show that, with the exception of the districts in the eastern region, regional statistics provide sufficient data for the disaggregation of regions into SAM, at least in terms of production and final consumption of public administration and households. This is achieved through nationally integrated markets, with markets intermediating regional production and consumption and thus offering the possibility of using different levels of disaggregation for production, on the one hand, and final consumption, on the other. At the same time, the method is not sufficient to determine intra-regional economic flows as well as the connections of domestic regions with foreign trade regions.

Table 0.1. Resources in the Resources-Uses Table (quadrant 1), year 2019, million MDL

Goods	Output	Proce-ssing services	Import	Excise and other indirect taxes	VAT	Trade margin	Transport margin	Customs tariff	Product subsidies	Total resources
AGR	35285	169	4265	5	1057	4554	108	604	687	45359
EXT	1027		4708	1	255	655	156	54	0	6855
PRE	61960	4512	89131	6202	15209	45950	3879	1140	0	227985
UTI	14190		0	4	89	169	95		0	14546
CON	40865		375	1	387		0		0	41628
COM	50425		294	6	1854	-51328	0		0	1250
TRA	22091		7007	1	597		-4238		326	25132
HOR	4286		0	1	92				0	4379
TIC	15178		1609	0	545				0	17333
FIN	10212		303	0	88				0	10603
IMO	19777		0	1	61				0	19839
SPR	11973		3119	1	74				0	15167
ADM	11269		515	0	0				0	11784
EDU	13113		1077	0	0				0	14190
SAN	11849		368	0	0				0	12218
SPE	8223		3647	1	0				12	11859
Total	331723	4681	116418	6222	20308	0	0	1798	1025	480126

Sources: calculated by the author.

Thus, a satisfactory modeling of the VAT and excise duties chain was achieved, even though uncertainties persist on the parameters of fiscal deductibility of these taxes at the level of production activities. The national sources do not provide any evidence to allow the calibration of this parameter by standard methods, the values being established by expert assessment based on the provisions of the Fiscal Code.

Table 0.2. Uses in the Resources-Uses Table (quadrant 2), year 2019, million MDL

Activity		Intermediary consumption																Final consumption		GFCF	Stock ch.	Export	Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Public admin.	House-holds				
AGR	1	4237	0	6184	0	116	107	0	260	0	0	0	15	192	29	48	66	417	17528	947	95	15118	45359
EXT	2	97	0	701	883	1011	106	24	26	10	2	73	8	3	122	103	44	0	3417	0		227	6855
PRE	3	8415	330	30770	3558	19059	5739	6599	1025	1966	461	2043	2748	2217	1899	2678	2080	133	94702	14809	222	26532	227985
UTI	4	169	31	1469	1666	222	1038	331	253	694	95	589	109	133	558	310	338	892	5651	0		0	14546
CON	5	0	11	687	196	492	199	226	57	197	207	197	188	147	300	202	88	0	2561	35582		89	41628
COM	6	0	0	258	67	33	165	146	12	34	52	42	119	27	7	19	5	0	166	0		97	1250
TRA	7	186	94	1292	226	343	2485	2766	19	399	75	79	404	223	73	79	82	0	9191	0		7115	25132
HOR	8	6	1	89	62	174	334	205	3	31	12	22	104	47	67	23	134	0	3065	0		0	4379
TIC	9	55	1	329	258	204	417	316	90	938	155	221	387	197	85	108	114	0	7226	1674		4559	17333
FIN	10	722	12	674	449	308	2004	389	52	321	1183	315	113	173	63	117	114	0	3514	0		80	10603
IMO	11	63	6	803	112	831	3251	629	113	241	91	605	499	476	135	48	188	0	11746	0		0	19839
SPR	12	104	2	811	221	48	1810	232	87	276	194	270	468	133	350	147	148	1393	5590	0		2882	15167
ADM	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8256	3002	0		526	11784
EDU	14	0	0	29	19	5	38	20	6	33	9	3	42	4	35	32	1	10624	2386	0		904	14190
SAN	15	3	0	0	0	0	6	0	0	0	0	0	0	0	0	193	0	9171	2364	0		481	12218
SPE	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1080	5089	0		5690	11859
Total		14056	490	44095	7717	22846	17698	11882	2001	5139	2538	4459	5204	3974	3724	4105	3401	31966	177199	53013	317	64301	480126

Sources: calculated by the author.

Table 0.3. Operating account in the Resources-Uses Table (quadrant 3), year 2019, million MDL

Component	AGR	EXT	PRE	UTI	CON	COM	TRA	HOR	TIC	FIN	IMO	SPR	ADM	EDU	SAN	SPE	Total
Gross value added	21398	537	22378	6472	18019	32727	10209	2285	10039	7674	15318	6768	7295	9389	7744	4821	183074
Employees' remuneration	2706	216	12135	3298	3763	14827	5171	1279	5191	2687	1094	3668	6597	9130	6846	2037	80645
Wages	2216	190	10201	2692	3214	13241	4433	1177	3626	2248	950	3000	5886	7263	5618	1829	67784
Social contributions	489	26	1934	606	549	1586	739	102	1564	439	145	668	710	1867	1228	209	12861
Taxes on production	133	16	181	118	165	476	145	51	173	0	131	60	0	0	0	8	1656
Subsidies on production	15	0	0	0	0	0	32	0	23	0	0	21	0	0	0	37	129
Gross operating surplus / mixed income	18575	305	10061	3057	14091	17425	4925	955	4697	4987	14092	3061	699	259	898	2814	100901

Sources: calculated by the author.

The micro-SAM obtained on the basis of the IOT provides a credible and informative picture of the main economic flows in the national economy. At the same time, some questions remain regarding the economic and statistical interpretation of the fact that, for more than a decade, the household sector has been demonstrating a chronic and growing financing need, provided that the sources of financing for this persistent deficit are not at all obvious.

The author has made some changes to the mathematical structure of the reference models in order for REMMO to meet the research objectives. The paper uses the standard notation from the IFPRI model.

The author aimed to introduce commercial regions, following a treatment similar to (Fortuna & Rege, 2010). For this, imports of each product *c* from each region *r*are first modeled, subsequently amalgamated into an aggregate import product c. Imports of the product *c* from region *r* are specified in CIF prices. According to Equation 1, the border price $PMR_{c,r,t}$ of the product *c* imported from the trading region *r* in period *t*, is determined by the international import price of the region $pwmr_{c,r,t}$ expressed in US dollars and the customs tariff $tmr_{c,r,t}$. Based on the exchange rate EXR_t of the national currency against the US dollar, the regional price is recalculated in lei.

(Ecuation 1.) $PMR_{c,r,t} = pwmr_{c,r,t} \cdot (1 + tmr_{c,r,t}) \cdot EXR_t$

The border import price $PMB_{c,t}$ (Equation 2) of the total quantity $QM_{c,t}$ of product *c* imported is a weighted average of the regional import prices.

(Ecuation 2.) $PMB_{c,t} = \frac{\sum_r PMR_{c,r,t} \cdot QMR_{c,r,t}}{QM_{c,t}}$

The imported product is delivered to the final producer at the consumer price $PMD_{c,t}$ of Equation 3 including trade and transport margins. In Equation 3, $PQ_{ct,t}$ represents the price of the transactional service ct, and $icm_{ct,c,t}$ is the quantity of the transactional service *ct* used per unit of imported good *c*.

(Ecuation 3.) $PMD_{c,t} = PMB_{c,t} + \sum_{ct} PQ_{ct,t} \cdot icm_{ct,c,t}$

The treatment of exports is similar. The local product *c* can be exported to the region *r* for the price $PER_{c,r,t}$ or delivered to the domestic market. Equations 4-6 describe the formation of export price $PEB_{c,t}$ and producer price $PES_{c,t}$, which are different because producers bear the costs of delivering product *c* at the border.

(Ecuation 4.) $PER_{c,r,t} = pwer_{c,r,t} \cdot EXR_{r,t}$

(Ecuation 5.) $PEB_{c,t} = \frac{\sum_r PER_{c,r,t} \cdot QER_{c,r,t}}{QE_{c,t}}$

(Ecuation 6.) $PES_{c,t} = PEB_{c,t} - \sum_{ct} PQ_{ct,t} \cdot ice_{ct,c,t}$

The import quantities $QM_{c,t}$ and of local $QD_{c,t}$ of product *c* form a Armington-type composite good delivered to the final consumer at the price $PQ_{c,t}$. The specification of this price in Equation 7 starts from the fact that the final consumer price includes the value added tax at the effective rate $tva_{c,t}$.

(Ecuation 7.) $PQ_{c,t} = \left[\frac{PDD_{c,t} \cdot QD_{c,t} + PMD_{c,t} \cdot QM_{c,t}}{QQ_{c,t}} + tacc_{c,t} - sc_{c,t}\right] \cdot (1 + tva_{c,t})$

In Equation 8 the author determines the $DTVA_{a,t}$ value of the VAT deductions for the purchased goods and services to which the producers from activity *a* are entitled, and in Equation 9 - the excise deductions. The parameter $scutva_{a,t}$ ($scutacc_{a,t}$) determines the proportion in which the producer *a* is exempt from VAT (excise duties) without the right to deduct. $QINT_{c,a,t}$represents the quantity of product *c* used as intermediate consumption by activity *a*, the summation being made on all goods and services used as intermediate consumption. VAT deductions are applied ad valorem and excise duty deductions - in proportion to the physical quantity used, which reflects the national fiscal policy.

(Ecuation 8.) $DTVA_{a,t} = (1 - scutva_{a,t}) \cdot \sum_c tva_{c,t} \cdot PQ_{c,t} \cdot QINT_{c,a,t}$

(Ecuation 9.) $DTACC_{a,t} = = (1 - scutacc_{a,t}) \cdot \sum_c tacc_{c,t} \cdot QINT_{c,a,t}$

Equation 10 determines the unit price $PINTA_{a,t}$of the composite good used as intermediate consumption in activity *a*. The parameter $ica_{c,a}$ represents the quantity of good *c* per unit of intermediate consumption in activity a $QINTA_{a,t}$ is the total amount of intermediate input in activity *a*. Thus, as shown in Equation 10, the unit price of the intermediate composite is adjusted "downwards" by the value of the unit deduction of VAT and excise duties to which the producer is entitled a.

(Ecuation 10.) $PINTA_{a,t} = \sum_c PQ_{c,t} \cdot ica_{c,a} - \frac{DTVA_{a,t} + DTACC_{a,t}}{QINTA_{a,t}}$

In determining the price of the gross value added $PVA_{a,t}$, the Equation 11 expressly introduces the subsidies on production $sa_{a,t}$. In Equation 11, $ta_{a,t}$ represents the effective rate of other taxes on production paid by the producer a, and $[\![QVA_{a,t}$ - the amount of gross value added produced in the activity a.

(Ecuation 11.) $PVA_{a,t} = \frac{PA_{a,t} \cdot QA_{a,t} \cdot (1 - ta_{a,t} + sa_{a,t}) - PINTA_{a,t} \cdot QINTA_{a,t}}{QVA_{a,t}}$

Production block modeling follows the specific approach for most general equilibrium models and applies the concept of nested production functions. As illustrated in Figure 0.1, this concept assumes that at different levels of production various functional forms can be used to aggregate factors of production and intermediate consumption.

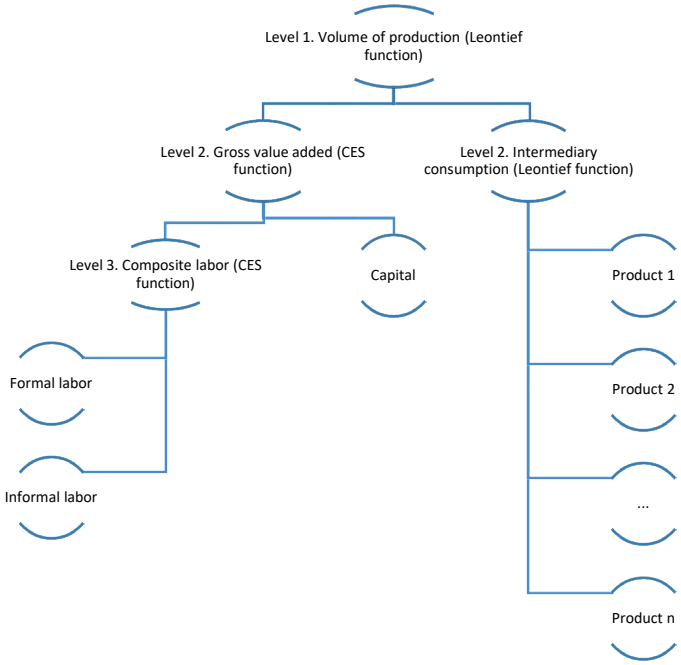

Figure 0.1. Concept of nested production function

Source: developed by author based on (Lofgren, Lee Harris, & Robinson, 2002) and (Dixon & Rimmer, 2002).

At top hierarchical level, the production volume of each activity is modeled as a Leontief-type production function (Equations 13-14). The coefficients iva_a and $inta_a$ show that the value added / intermediate consumption ratio is constant.

(Ecuation 12.) $QVA_{a,t} = iva_a \cdot QA_{a,t}$

(Ecuation 13.) $QINTA_{a,t} = inta_a \cdot QA_{a,t}$

At the second level of the production function, the contributions of the primary factors of production (QL composite labor and QK capital) in generating value added are determined on the basis of a classical CES function (Equation 14). The given equation determines the amount of value added for any combination of composite labor and capital factors. In Equation 14, $\alpha va_{a,t}$ is the total productivity of the factors that generate the gross added value, $QL_{a,t}$ is the amount of composite labor used in the activity a, $prdl_{a,t}$ is the specific productivity of the composite labor factor, and δva_a is the weight associated with this factor. $QK_{a,t}$ is the physical amount of capital used in activity a, and $prdk_{a,t}$ is the specific productivity of capital. The parameter ρva_a is the exponent of the CES function and is obtained by a transformation of the elasticity of the technological substitution σva_a between

the labor factor and the capital factor: $\rho va_a = \frac{\sigma va_a - 1}{\sigma va_a}$. A value of the parameter ρva_a closer to zero corresponds to a classical Cobb-Douglas function, and a value tending to -∞ corresponds to a Leontief function.

(Ecuation 14.) $$QVA_{a,t} = \alpha va_{a,t} \cdot \left[\delta va_a \cdot \left(prdl_{a,t} \cdot QL_{a,t}\right)^{-\rho va_a} + (1 - \delta va_a) \cdot \left(prdk_{a,t} \cdot QK_{a,t}\right)^{-\rho va_a}\right]^{-\frac{1}{\rho va_a}}$$

(Ecuation 15.) $$\frac{QL_{a,t}}{QK_{a,t}} = \left(\frac{prdl_{a,t}}{prdk_{a,t}} \cdot \frac{\delta va_a}{1-\delta va_a} \cdot \frac{WK_{a,t}}{WL_{a,t}}\right)^{\sigma va_a}$$

Equation 15 is obtained by deriving Equation 14 in relation to each factor of production and by fixing the marginal cost of the factor f in the activity a at the level of the marginal income generated by the factor. $WK_{a,t}$is the remuneration obtained from capital, $WL_{a,t}$- the remuneration of the labor-composite factor. Mathematically, Equation 15 represents the necessary condition for the existence of the local maximum of the function of the profit obtained by the producer from the generation of added value (Chiang, 1984).

Taking into account the socio-economic peculiarities of the Republic of Moldova, the labor-composite factor is modeled as composed of 2 subfactors: formal labor (where taxes, relevant contributions and benefits are calculated, withheld and paid) and informal labor (which involves taxes and very small contributions). The author assumed that there is a certain substitutability relationship between the two factors, therefore, the aggregation of the two subfactors-labor is performed within a CES-type function (Equation 16). In this equation, $\alpha l_{a,t}$ is the total productivity of the subfactors; $QLF_{a,t}$ is the amount of formal work used in activity a; δl_a is the share associated with this subfactor; $prdlf_{a,t}$ is the specific productivity of the given subfactor; $QLI_{a,t}$ is the amount of informal labor subfactor used in activity a; and $prdli_{a,t}$ - the specific productivity associated with it. The parameter ρl_a is a substitution parameter obtained by a transformation of the elasticity of the technological substitution between formal and informal work. The optimal proportions between the two subfactors are determined by Equation 17, obtained analogous to Equation 15, from the condition of existence of the local maximum.

(Ecuation 16.) $$QL_{a,t} = \alpha l_{a,t} \cdot \left[\delta l_a \cdot \left(prdlf_{a,t} \cdot QLF_{a,t}\right)^{-\rho l_a} + (1 - \delta l_a) \cdot \left(prdli_{a,t} \cdot QLI_{a,t}\right)^{-\rho l_a}\right]^{-\frac{1}{\rho l_a}}$$

(Ecuation 17.) $$\frac{QLF_{a,t}}{QLI_{a,t}} = \left(\frac{prdlf_{a,t}}{prdli_{a,t}} \cdot \frac{\delta l_a}{1-\delta l_a} \cdot \frac{WLI_{a,t}}{WLF_{a,t}}\right)^{\sigma l_a}$$

In REMMO, capital is modeled as a homogeneous (non-composite) factor.

The local product $QX_{c,t}$ can be supplied to two alternative markets: local ($QD_{c,t}$) or external (($QE_{c,t}$). The quantity of product exported $QE_{c,t}$ is aggregated from regional exports under a CET function, determined by Equation 18. The optimal quantities to be allocated to different trade regions maximize export

earnings and depend on relative prices and their reciprocal transformability, as specified in Equation 19. An assumption underlying Equations 18 and 19 is the multilateral symmetry of regional export transformability.

(Ecuation 18.) $$QE_{c,t} = \alpha e_{c,t} \cdot \left[\sum_r \delta e_{c,r} \cdot QER_{c,r,t}^{\rho e_c}\right]^{\frac{1}{\rho e_c}}$$

(Ecuation 19.) $$\frac{QER_{c,r,t}}{QE_{c,t}} = \left(\frac{PER_{c,r,t}}{PEB_{c,t}} \cdot \frac{1}{\delta e_{c,r} \cdot (\alpha e_{c,t})^{\rho e_c}}\right)^{\frac{1}{\rho e_c - 1}}$$

An analog modeling sequence is applied to the mix of local and imported products. The local product $QD_{c,t}$ is not perfectly identical to the imported one$QM_{c,t}$, thus forming a good Armington type composite, modellable according to a classic CES function. The aggregation of regional imports $QMR_{c,r,t}$ in the imported aggregate $QM_{c,t}$ occurs under an CES function (Equation 20). The objective function is to minimize the cost of the imported aggregate, which leads to Equation 21 which expresses the optimal weights of the regions in total imports to reach this minimum cost.

(Ecuation 20.) $$QM_{c,t} = \alpha m_{c,t} \cdot \left[\sum_r \delta m_{c,r} \cdot QMR_{c,r,t}^{-\rho m_c}\right]^{-\frac{1}{\rho m_c}}$$

(Ecuation 21.) $$\frac{QMR_{c,r,t}}{QM_{c,t}} = \left(\frac{\delta m_{c,r}}{(\alpha m_{c,t})^{\rho m_c}} \cdot \frac{PMB_{c,t}}{PMR_{c,r,t}}\right)^{\frac{1}{1+\rho m_c}}$$

Equation 22 illustrates the formation of the income of factor *f* as a function of the level of remuneration $WF_{f,a,t}$ obtained by the factor in activity a and by the amount of factor *f* required by that activity. This specification is identical to that of the IFPRI model and the PEP model (Decaluwe, Lemelin, Robichaud, & Maisonnave, 2013).

(Ecuation 22.) $$YF_{f,t} = \sum_a WF_{f,a,t} \cdot QF_{f,a,t}$$

Income of factor *f*, after transfers to the rest of the world (e.g. remuneration of non-resident workers) and after payment of individual social security contributions at the effective rate $tcnas_{f,t}$ and health insurance at the effective rate $tcnam_{f,t}$, is distributed to the institutional sectors that supply the factor f (Equation 23). The share $SHIF_{i,f,t}$ of institution i in the income of factor f is equal to the share of factor $QFI_{i,f,t}$ in the total stock of factor f (Equation 24).

(Ecuation 23.) $$YIF_{i,f,t} = SHIF_{i,f,t} \cdot \left(1 - tcnam_{f,t} - tcnas_{f,t}\right) \cdot YF_{f,t} - \sum_r \left(trnsfr_{r,f,t} \cdot EXR_{r,t}\right)$$

(Ecuation 24.) $$SHIF_{i,f,t} = {QFI_{i,f,t}}\Big/{\sum_{i'} QFI_{i',f,t}}$$

REMMO distinguishes between different levels of public administration. Thus, own revenues $YG_{g,t}$ of the governmental institutional sector *g* are formed by the taxes and fees collected by it, the level of fiscal revenues depending both on the effective tax rate (parameter) and on the size of the taxable base and the share of sector g in total GNP receipts from that tax (Equation 25). The quotas related to the governmental level g are abbreviated with *shg* + the name of the respective tax /

fee. Government revenues also include current transfers received from other domestic institutions (including revenues from intra-government transfers) and from abroad, and revenues from factors held.

(Ecuation 25.) $$YG_{g,t} = shgtins_{g,t} \cdot \sum_{idp} tins_{idp,t} \cdot YI_{idp,t} + shgcnam_{g,t} \cdot \sum_{f} tcnam_{f,t} \cdot YF_{f,t} + shgcnas_{g,t} \cdot \sum_{f} tcnas_{f,t} \cdot YF_{f,t} + shgtva_{g,t} \cdot \sum_{c} tva_{c,t} \cdot \left[PDD_{c,t} \cdot QD_{c,t} + PMD_{c,t} \cdot QM_{c,t} + \left(tacc_{c,t} - sc_{c,t}\right) \cdot QQ_{c,t}\right] - shgtva_{g,t} \cdot \sum_{a} DTVA_{a,t} + shgtacc_{g,t} \cdot \sum_{c} tacc_{c,t} \cdot QQ_{c,t} - shgtacc_{g,t} \cdot \sum_{a} DTACC_{at} + shgta_{g,t} \cdot \sum_{a} ta_{a,t} \cdot PA_{a,t} \cdot QA_{a,t} + shgtmr_{g,t} \cdot \sum_{c,r} tmr_{c,r,t} \cdot pwmr_{c,r,t} \cdot QMR_{c,r,t} \cdot EXR_{t} + \sum_{f} YIF_{g,f,t} + \sum_{g'} trnsfr_{g,g',t} \cdot \overline{CPI}_{t} + EXR_{t} \cdot \sum_{r} trnsfr_{g,r,t}$$

Equation 26 models the current government sector expenditure g. These include government consumption expenditure $\sum_c PQ_{c,t} \cdot QG_{g,c,t}$), expenditure on product subsidies and for production subsidies, transfers made by the government sector g to the rest of the domestic institutions and which are indexed to the level of consumer prices ($\sum_{idp} trnsfr_{idp,g,t} \cdot \overline{CPI}_t$) and expenditure for intergovernmental transfers.

(Ecuation 26.) $$EG_{g,t} = \sum_{c} PQ_{c,t} \cdot QG_{g,c,t} + shgsc_{g,t} \cdot \sum_{c} sc_{c,t} \cdot QQ_{c} + shgsa_{g,t} \cdot \sum_{a} sa_{a,t} \cdot PA_{a} \cdot QA_{a} + \sum_{idp} trnsfr_{idp,g,t} \cdot \overline{CPI}_{t} + \sum_{g'} trnsfr_{g',g,t} \cdot \overline{CPI}_{t} + EXR_{t} \cdot \sum_{r} trnsfr_{r,g,t}$$

The dynamics of the available capital stock at the level of economic activity is determined following an approach similar to the one applied by (Thurlow, 2004). The capital stock $QK_{a,t}$ available in period t is determined by the stock from the previous period $QK_{a,t-1}$ remaining available after deducting the depreciated capital plus the new capital addition $DK_{a,t}$ to sector a.

(Ecuation 27.) $$QK_{a,t} = QK_{a,t-1} \cdot \left(1 - \delta_{a,t}\right) + DK_{a,t}$$

The contribution of new capital in activity *a*, is determined by Equation 28. In that equation, the variable $ACTKSHR_{a,t}$means the share of activity a in the global capital investment made in the entire economy in the current period. This specification is based on the assumption that the overall investment $\sum_{c,t} PQ_{c,t} \cdot QINV_{c,t}$ is technologically homogeneous and that there is a price specific to capital PK_t.

(Ecuation 28.) $$DK_{a,t} = ACTKSHR_{a,t} \cdot \frac{\sum_{c,t} PQ_{c,t} \cdot QINV_{c,t}}{PK_t}$$

(Ecuation 29.) $$PK_t = \sum_{c,t} PQ_{c,t} \cdot shrinvcom_{c,t}$$

These structural details inevitably posed the problem of estimating a large number of elasticity parameters. It was found that the time series available in the national statistical sources provide sufficient evidence only to estimate a small number of Armington coefficients of elasticity of the REMMO model, while other parameters could only be taken from the literature.

Chapter 3 of the thesis - **Simulating the impact of macroeconomic policy shocks on the general equilibrium in the national economy** - presents the results of the simulations of three macroeconomic policy shocks. This chapter presents the results of several policy scenario simulations that test the response of the economy to policy reforms that are currently on the agenda of national authorities. In particular, systemic impact of an increase in the VAT rate for agricultural products, the liberalization of Moldova's trade with the People's Republic of China and a structural reform leading to the facilitation of international trade by lowering transaction costs were analyzed.

Overall, the results clearly show that REMMO is a suitable quantitative analysis tool for ex-ante policy impact assessment. Using such a tool, the decision maker can identify and understand the complex interactions of many economic factors and assess the net effect of policy intentions on output (Table 0.4), macroeconomic indicators (Table 0.5) and population welfare (Table 0.6), which is much more difficult to achieve in a partial equilibrium analysis. Preliminary assumptions based on conventional intuition were formulated for each of these scenarios. The objective results of the REMMO-based simulations validated some hypotheses and invalidated others.

Table 0.4. Impact of policy scenarios on the real GDP and its components

Component	INITIAL, billion MDL	Average annual growth rate, %					
		BAU	TVA	CHIMP	CHEXP	CHTOT	MARJ
Absorption	263.031	2.978	2.949	2.989	2.979	2.990	3.260
Private consumption	177.428	2.654	2.616	2.666	2.655	2.667	2.945
Investment	53.177	2.801	2.793	2.812	2.802	2.813	3.076
Government consumption	32.108	4.889	4.871	4.898	4.890	4.899	5.142
Exports	64.800	4.887	4.840	4.912	4.886	4.912	5.369
Imports	-116.767	2.964	2.934	2.981	2.966	2.983	3.283
GDP	211.064	3.605	3.571	3.618	3.606	3.619	3.937
Net taxes on products and production	29.082	2.135	2.108	2.150	2.137	2.152	3.866
Gross value added	181.982	3.824	3.788	3.837	3.824	3.837	3.948

Source: REMMO-based simulation results;

Table 0.5. Impact of policy scenarios on key macroeconomic indicators

	INITIAL	BAU	TVA	CHIMP	CHEXP	CHTOT	MARJ
Real effective exchange rate	100	-1.55	-1.29	-1.55	-1.19	-1.19	-2.02
Nominal effective exchange rate	100	-2.26	-2.36	-2.15	-2.27	-2.15	-1.52
Industrial producers' prices index	100	-0.72	-1.08	-0.6	-0.71	-0.6	0.51
Terms of trade index	100				1.07	1.07	
Investment, % of GDP	25.04	-1.32	-1.31	-1.32	-1.32	-1.32	-1.4
Foreign savings, % of GDP	8.97	-2.48	-2.46	-2.48	-2.48	-2.48	-2.63
Trade deficit, % of GDP	25.24	-6.77	-6.74	-6.93	-6.77	-6.93	-7.19
Budgetary deficit, % of GDP	-1.8	3.07	3.43	2.94	3.07	2.94	3.29

Source: REMMO-based simulation results;

Table 0.6. Impact of policy scenarios on households' consumption expenditures

Teritory	INITIAL, billion MDL	Average annual growth rate, %					
		BAU	TVA	CHIMP	CHEXP	CHTOT	MARJ
Anenii Noi	5.15	1.75	1.72	1.77	1.75	1.77	1.99
Călărași	1.88	1.91	1.88	1.92	1.91	1.92	2.15
Criuleni	3.14	2.13	2.08	2.14	2.13	2.14	2.42
Dubăsari	1.16	2.01	1.99	2.03	2.02	2.03	2.25
Hâncești	4.39	1.78	1.74	1.79	1.78	1.79	2.03
Ialoveni	3.92	2.29	2.26	2.31	2.29	2.31	2.57
Nisporeni	4.14	2	1.96	2.01	2	2.01	2.27
Orhei	7.08	2.05	2.01	2.06	2.05	2.06	2.32
Rezina	2.18	2.82	2.77	2.84	2.82	2.84	3.16
Strășeni	5.17	2.19	2.15	2.2	2.19	2.2	2.46
Șoldănești	1.83	2.24	2.19	2.25	2.24	2.25	2.53
Telenești	2.81	1.81	1.77	1.82	1.81	1.82	2.05
Ungheni	6.26	2.43	2.38	2.45	2.43	2.45	2.73
Chișinău	62.82	3.05	3.04	3.06	3.05	3.06	3.38
Bălți	5.41	2.68	2.67	2.69	2.68	2.69	2.97
Briceni	4.22	2.34	2.29	2.36	2.34	2.36	2.64
Dondușeni	1.95	2.86	2.78	2.88	2.86	2.88	3.24
Drochia	4.65	2.58	2.53	2.6	2.58	2.6	2.89
Edineț	4.09	1.96	1.93	1.97	1.96	1.97	2.22
Fălești	3.46	2.24	2.19	2.25	2.24	2.25	2.53
Florești	3.67	2.34	2.29	2.35	2.34	2.35	2.63
Glodeni	0.75	2.75	2.74	2.76	2.75	2.76	3.03
Ocnița	3.09	1.64	1.59	1.65	1.64	1.65	1.91
Râșcani	1.45	2.2	2.17	2.21	2.2	2.21	2.46
Sângerei	3.2	1.86	1.83	1.87	1.86	1.87	2.1
Soroca	4.88	1.54	1.52	1.55	1.54	1.55	1.75
Basarabeasca	1.12	2.23	2.2	2.24	2.23	2.24	2.5

Cahul	3.22	2.09	2.07	2.1	2.09	2.1	2.34
Cantemir	2.32	2.64	2.59	2.66	2.65	2.66	2.97
Căușeni	2.16	1.97	1.95	1.98	1.97	1.98	2.23
Cimișlia	2.23	1.97	1.94	1.98	1.97	1.98	2.22
Leova	2.57	2.27	2.23	2.28	2.27	2.28	2.55
Ștefan Vodă	2.36	1.96	1.92	1.97	1.96	1.97	2.23
Taraclia	2.45	2.08	2.03	2.09	2.08	2.09	2.35
UTA Găgăuzia	6.16	2.11	2.08	2.11	2.11	2.12	2.37

Source: REMMO-based simulation results;

REMMO thus shows that the policy of increasing the VAT for agricultural products (denoted with acronym TVA in tables 0.4-0.6) leads to the increase of revenues in the state budget, but deprives other components of the budgetary system of a part of revenues, including, of the budgets of administrative-territorial units at both levels. Moreover, this policy can even lead to a decrease in exports, which could hardly be foreseen without resorting to the analysis of the general economic equilibrium. Household consumption compresses in relatively uniform manner by geographic territories, as the structure of consumption expenditure is quite homogeneous in geographical perspective. But things can change if the distributive impact is assessed against the socio-economic criterion instead. Agricultural products have a much higher share in the consumption expenditures of poor households than in the case of richer ones. Therefore, the increase in the VAT rate could be disproportionately strong, especially in lower-income households. If the government adopts such a policy, it will be necessary to adopt either well-targeted compensation policies as part of the social aid program for losses incurred by disadvantaged households, or the combination of fiscal policy with structural measures increasing the productive capacity of low-income sectors (especially agriculture).

The results of each of the scenarios were interpreted in the theory of general equilibrium. For example, one of the pertinent questions that may arise in relation to the results of the VAT scenario is why should exports decrease, as REMMO suggests? Apparently, VAT has no direct link with exports and should not have influenced them. To elucidate this particular result, the author used an analytical approach similar to that of (Hosoe, Gasawa, & Hideo, 2010) and relied on a simple model of an open economy that is supposed to produce a single agricultural product (Figure 0.2).

The initial equilibrium point A_0 reflects the point of tangency of the budget line to the consumer indifference curve for imported and local goods and to the consumption possibilities curve. The location of this point depends essentially on the ratio of domestic / import consumer prices (PD / PM). Doubling the VAT rate on agricultural products reduces consumer resources for products of both origins, thus shifting the budget line inward (revenue effect).

However, the model suggests that, in addition, there is a readjustment of the PD / PM price ratio, with domestic prices increasing immediately following the shock by 0.14% compared to the BAU scenario, while import prices, on the other

hand, decrease by 0.22%, practically exclusively due to a faster appreciation of the national currency in relation to the BAU situation. Thus, there is a relative change in the composite agricultural product, the demand for local agricultural goods decreasing by 2.9%, while for imported agricultural goods, by 2.5%, with the balance shifting from A_0 to A_1.

At the same time, according to the REMMO results, the impulse on export prices is a decrease of 0.13% compared to the BAU scenario. Because export prices fall less than import prices, the line of the export / import price ratio in quadrant 1 in Figure 0.2 rotates counterclockwise. On the other hand, the line of the export / local price ratio is flattening, as domestic prices rise, while export prices, on the other hand, fall. As a result, export supplies decrease by 3.2% compared to BAU, while supplies on the local market - by 2.9%, and the equilibrium point between goods delivered locally and those delivered for export on the production capacities frontier moves from B_0 to B_1.

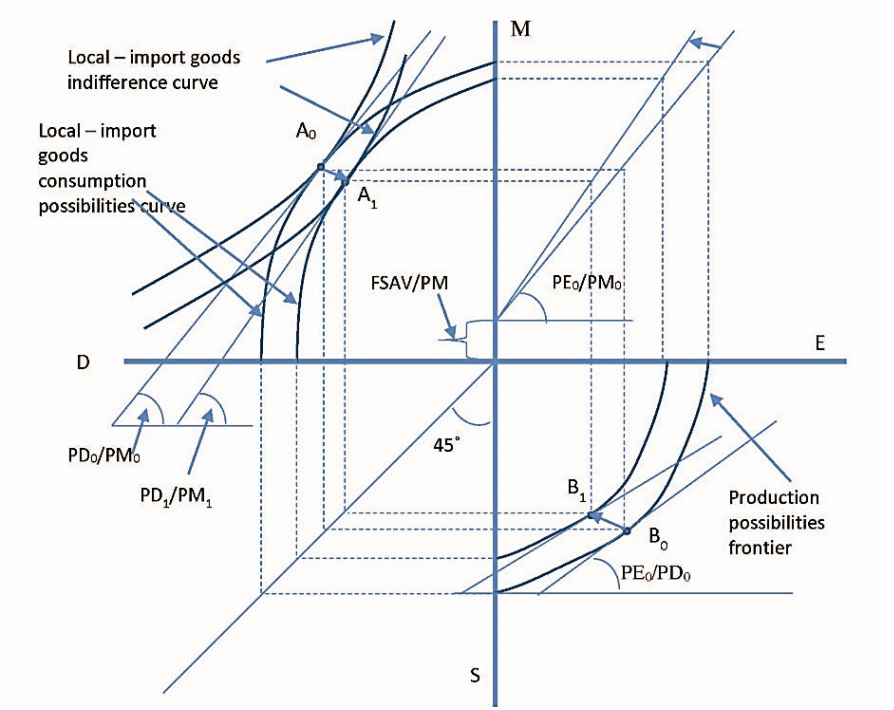

Figure 0.2. Brief theoretical interpretation of the results of the VAT increase scenario for agricultural products

Source: developed by author.

In the scenario of trade liberalization with China, some results are contrary to those initially anticipated. For example, the increase in imports (acronym CHIMP) does not lead to a fall in domestic production - on the contrary, even agricultural and industrial producers could benefit from cheaper imported raw materials, not to mention the fact that the welfare of consumers as a whole is increasing. This is largely explained by the fact that China does not play a large role in imports of the domestic economy. On the other hand, China has an even smaller share as a destination for Moldovan exports. That is why the impact of liberalizing the access of Moldovan exporters to the Chinese market (acronym CHEXP), even if positive, is not significant. However, this could change with the increase of the export capacities of the Republic of Moldova. The full scenario of bilateral liberalization (acronym CHTOT) is thus almost completely determined by the CHIMP component. The analysis framework can be easily extended to analyze ex-ante the impact of other possible free trade agreements. Overall, however, the results of the simulations clearly confirm the positive impact of trade liberalization as predicted by international trade theory.

In scenario three (acronym MARJ), the hypotheses are confirmed by the results of the REMMO-based simulations. Reducing transaction costs across the economy has a major positive impact on virtually all economic activities, including the transport sector. The transport sector successfully internalizes the losses caused by the imposition of a smaller margin and is ultimately benefiting from the net positive economic effects of these policy measures. The trade sector is the only one to lose in that structural policy and this is due to the very large trade margin applied by the sector in the initial situation. At the same time, the welfare gains that occur in this policy scenario are positive in all regions, even though the large urban areas - where the main industrial capacities are located - have slightly higher gains than rural localities.

Qualitatively, the conclusions remain relevant regardless of the factor market closure rules, but quantitatively, the results differ greatly. A good understanding of the mechanisms guiding the dynamics of the labor market is essential for stronger quantitative benchmarks in the analyzed scenarios.

The combination of the results from the analyzed scenarios offers an important suggestion regarding the long-term economic strategy. It is known from economic theory and policy practice that any tax inevitably reduces the efficiency of resource allocation throughout the economy, and increasing them increases the efficiency losses even more. Any attempts to compensate for tax losses incurred through subsidies or compensatory payments may undermine the initial objectives of the more austere fiscal policy, for example, the goal of reducing the budget deficit. However, in combination with a structural reform, such as the one modeled by scenario three, a more austere fiscal policy can be implemented with much lower or even zero efficiency losses.

CONCLUSIONS AND RECOMMENDATIONS

The results obtained in the research allow a deeper understanding of the impact of macroeconomic policies on the general economic equilibrium in the Republic of Moldova, in particular, budgetary-fiscal, trade and structural policies. Starting from the objectives set in the research, the author reaches the following conclusions:

1. ***General Equilibrium Theory provides a solid foundation*** for the CGE models, one that allows them to be coherent quantitative economic analysis tools, both from a microeconomic and macroeconomic point of view, easily applicable even in the conditions of the Republic of Moldova.
2. Despite their diversity, ***CGE models have several conceptual blocks in common***: prices, production, trade, formation and use of institutional unit revenues, system constraints, possibly (in the case of dynamic models) a block that models the model dynamics. This conceptual structure allows the adaptation and transformation of models to respond to a wide range of applications.
3. For the compilation of Social Accounting Matrices, ***it is necessary to reconcile a very wide range of statistical data***. Significant challenges are related to the absence of data and indicators that may prove critical for the aggregation of the CGE data set. The author applied a series of mathematical methods for the probabilistic compilation of missing data, updating IOT at the level of macroeconomic data for 2019 and inclusion in SAM of regional production and consumption. At the same time, the available time series do not provide a sufficient volume of statistical data for the econometric estimation of all elasticity parameters of a disaggregated model.
4. Most of the CGE models offer, as a mathematical structure, a high degree of adaptability to various research objectives. This allowed the author to use a number of internationally recognized standard models, such as the IFPRI model (Lofgren, Lee Harris, & Robinson, 2002), the PEP model (Decaluwe, Lemelin, Robichaud, & Maisonnave, 2013), the model for the Azores (Fortuna & Rege, 2010) as a core for compiling REMMOs as a dynamic-recursive synthetic CGE. Being essentially macroeconomic, REMMO ensures the inclusion of regional production and consumption and admits different levels of disaggregation of the included regions (development regions for production, districts / municipalities for consumption). It satisfactorily models the main taxes, contributions and subsidies, intra-government flows, includes transaction costs and disaggregates the "rest of the world" into five commercial regions.
5. As the concrete case of REMMO demonstrates, the ***quantitative instruments of the CGE class can be extremely informative and convenient*** for simulating the impact of budgetary-fiscal, trade and

structural policy shocks, even though in their static and dynamic-recursive versions they are less well adapted to monetary policy modeling. It is also possible to model the impact of completely exogenous shocks, such as climate-related, technological, epidemiological, etc. In particular, the author used REMMO to simulate the impact of three significant policy shocks: fiscal policy (raising the VAT rate on agricultural products up to the standard rate), trade policy (trade liberalization with China) and a supply-side structural policy (reduction of transaction costs).

6. The VAT shock impact simulation scenario confirms the theoretical and intuitive anticipations. As a result of this policy, the revenue to the state budget, the main destination of VAT payments, increases. At the same time, the fiscal impact on BUAT, BASS and FAOAM is negative, which is determined by the decrease of the revenues of these budgets from the income tax and from the mandatory social and medical insurance contributions. One of the limitations of the modeled scenario is that there is insufficient evidence on the parameters of VAT deductibility by producers at the level of disaggregated economic activities according to the classification adopted in SAM / REMMO.
7. In the case of the trade liberalization scenario, the results do not confirm the conventional expectations related to the reduction of bilateral tariff barriers by 75% for traded goods. Interpreted in the theoretical framework of general equilibrium, the results given are clear and solid. Thus, the reduction by the Republic of Moldova of tariff barriers on imports from China are not expected to have that negative impact that is traditionally feared by domestic producers who advocate more protectionist policies. Increased access of Moldovan exports to the Chinese market does not have a major impact due to the small volume of exports. The main uncertainties in this scenario are related to the size of the coefficients of elasticity of the export market - local market transformation.
8. The structural policy shock scenario validated fully the preliminary assumptions. A 10% reduction in trade and transport margins has a major systemic effect. GDP is growing sustainably, external and budgetary imbalances are correcting much faster than in the baseline scenario, and the well-being of households is growing across the country. At the same time, the results suggest that the welfare gains of households in large urban areas are higher than in rural areas. This can magnify, in the long run, income inequality and the geographical polarization of the national economy. In the case of this scenario, the main uncertainty is related to the actual size of trade and transport margins applied at sector level.
9. As the author's additional simulations show, the results of the three policy scenarios are quite sensitive to the exogenously applied labor market closure rule. Even if the differences are more quantitative than qualitative,

in some cases differ not only the size but also the direction of variation of some endogenous variables.

Based on these conclusions, a number of recommendations can be made:

1. To the National Bureau of Statistics.

- Compilation of an official IOT based on CAEM rev.2 and reflecting the situation for the most recent year possible;
- Providing more information on intra- and inter-regional economic flows;
- Verification of accounts in the SNA and completion of capital and financial accounts.

2. To the Ministry of Finance of the Republic of Moldova.

- The VAT increase on agricultural products must be implemented with caution.
- Offsetting austere fiscal policies by way of output enhancing structural policies.

3. To the Ministry of Economy of the Republic of Moldova.

- Trade liberalization with China is a legitimate policy and must be promoted.
- The facilitation of international trade must be actively promoted on a broad front as well.

The research based on the CGE model provided some suggestions regarding promising theoretical and practical directions in which it would be interesting to continue the effort.

1. Theoretical research directions. One of the most interesting issues that could be investigated is the issue of the ***representativeness of the agents*** included in the model.

2. Practical research directions (extension of REMMO):

- Inclusion of capital and financial accounts for the institutional sectors;
- Transition from integrated markets to regionally disaggregated markets;
- More nuanced estimation of trade and transport margins at sector level;
- Continuation of research for the robust determination of elasticity parameters;
- More refined treatment of factor market closure mechanisms;
- Adding demographic and environmental modules.

These additions will significantly increase the level of insight of the complex instruments developed in the thesis (IOT, SAM, REMMO). But even in the proposed formats, they can already be used for better coordination of macroeconomic policies both in inter-institutional terms (Government - NBM) and in terms of reconciling development objectives at the national level with those at the regional level.

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LIST OF PUBLICATIONS OF THE AUTHOR ON THE THESIS TOPIC

List of scientific publications on the thesis topic / synthesis work *

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1. Articles in scientific journals

1.1. in journals in other databases accepted by ANACEC

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ANNOTATION

To the thesis to obtain the scientific degree of doctor in economic sciences "Impact of the macroeconomic policies based on the computable general equilibrium model (the case of the Republic of Moldova)", Prohnițchi Valeriu, Specialty: 521.01. Economic theory and economic policies, Chisinau, 2021

Thesis structure: Introduction, three core chapters, general conclusions and recommendations chapter; bibliography including 116 sources, 14 figures, 39 tables, 21 tabular annexes. Research activities are reflected in 6 scientific publications.

Keywords: General economic equilibrium, computable general equilibrium model with geographical resolution, Social Accounting Matrix, system of national accounts, impact evaluation.

Research goal: Development of a coherent conceptual framework and adaptation of an applied mathematical economic model for impact evaluation of macroeconomic policy, with an emphasis on fiscal, trade and structural policies in Republic of Moldova.

Research objectives: Compilation of a set of data coherent in micro-, mezo- and macro-economic perspective, identification of structural interdependencies in the national economy; adaptation of a quantitative model for evaluation of the policy options; mathematical calibration and econometric estimation of model parameters; ex-ante simulation of the macroeconomic policy shocks and their impact evaluation.

Scientific novelty and originality: Deepening of the theoretical and practical research regarding systemic ex-ante impact evaluation of shocks; testing new modalities for integration of the regional economy and of decision-making process in the general equilibrium mechanisms; combination of the calibration and econometric methods for determination of structural and elasticity parameters.

Results contributing to the solution of an important scientific problem: Up-to-date Social Accounting Matrix with real economic flows developed for the national economy; geographical dimension introduced in the computable general equilibrium model; interaction between policy and real economy assessed; distributive impact of macroeconomic policies is evaluated in regional aspect.

Theoretical significance: Development of the methodological basis for the integration of the geographical dimension in the computable general equilibrium models; detailed representation of fiscal, trade and structural policy tools; disaggregation of the governmental flows by relevant administrative levels; theoretical interpretation of simulations results.

Applicative value: Computable general equilibrium model can be applied for ex-ante evaluation of the impact of macroeconomic policy in the national economy, especial tax, budgetary, trade and structural policies. The model also addresses the purpose of impact evaluation of the exogeneous shocks, such as natural, technological and epidemiological phenomena. The Social Accounting Matrix integrating real flows with regional dimension is in itself a result with potentially multiple uses in various applications.

Implementation of scientific results: Results of the research have been used for the training of the key staff of the Ministry of Finance of the Republic of Moldova in application of the computable general equilibrium models for the ex-ante impact evaluation of the fiscal policy. The model has been instrumental in economic evaluations as requested by the Ministry of Economy and Infrastructure (socioeconomic impact of the administrative restrictions imposed by COVID-19 pandemic), World Bank (impact of the Deep and Comprehensive Free Trade Agreement) and UN (impact of COVID-19 on the inter-generational economy).

ADNOTARE

La teza pentru obținerea gradului științific de doctor în științe economice „Impactul politicilor macroeconomice în baza modelului de echilibru general aplicat (cazul Republicii Moldova)”, Prohnițchi Valeriu, Specialitatea: 521.01. Teorie economică şi politici economice, Chișinău, 2021

Structura tezei: Introducere, trei capitole de bază, capitol de concluzii generale și recomandări, bibliografie compusă din 116 surse, 14 figuri, 39 tabele, 21 anexe tabulare. Cercetările efectuate au fost reflectate în 6 publicații științifice.

Cuvinte-cheie: Echilibru economic general, model de echilibru general aplicat cu rezoluție geografică, Matrice de Contabilitate Socială, sistem de conturi naționale, evaluare de impact.

Scopul lucrării: Dezvoltarea unui cadru conceptual coerent și adaptarea unui model economico-matematic aplicativ pentru evaluarea de impact a politicii macroeconomice, cu accent pe politicile fiscale, comerciale și structurale în Republica Moldova.

Obiectivele cercetării: Compilarea unui set de date coerent în aspect micro-, mezo- și macroeconomic; identificarea interdependențelor structurale în economia națională; adaptarea unui model cantitativ pentru evaluarea opțiunilor de politică; calibrarea matematică și estimarea econometrică a parametrilor modelului; simularea ex-ante a unor șocuri de politică macroeconomică și evaluarea impactului cantitativ și distributiv al acestora.

Noutatea şi originalitatea ştiinţifică: Aprofundarea cercetărilor teoretice și practice privind evaluarea ex-ante sistemică a impactului șocurilor; testarea unor modalități noi de integrare a regiunilor și de reprezentare a cadrului decizional în mecanismul de echilibru economic general; combinarea metodelor de calibrare matematică cu metodele de estimare econometrică a parametrilor structurali și de elasticitate a modelelor de echilibru general aplicat.

Rezultatele obținute care contribuie la soluționarea unei probleme științifice importante: A fost elaborată o Matrice de Contabilitate Socială cu fluxuri reale pentru economia națională; a fost elaborat model de echilibru general aplicat cu rezoluție geografică (REMMO); a fost elucidată interacțiunea dintre politici și economia reală; a fost cuantificat impactul distributiv al politicilor macroeconomice în aspect regional.

Semnificația teoretică: Dezvoltarea bazei metodologice pentru integrarea aspectului regional în modelele de echilibru general aplicat; reprezentarea detaliată a instrumentelor de politici fiscale, comerciale și structurale; detalierea fluxurilor sectorului guvernamental pe nivele administrative relevante; interpretarea teoretică a rezultatelor simulărilor.

Valoarea aplicativă: Modelul de Echilibru General Aplicat poate fi utilizat pentru evaluarea ex-ante a impactului politicilor macroeconomice în economia națională, în special a celor fiscale, bugetare, comerciale și structurale. Modelul este pretabil și pentru estimarea impactului unor șocuri de natură exogenă, cum ar fi fenomene naturale, tehnologice sau epidemiologice extreme. Matricea de Contabilitate Socială care integrează sectorul real dezagregat pe criterii geografice este un alt rezultat în sine care poate fi utilizat într-o serie de alte aplicații.

Implementarea rezultatelor ştiinţifice: Rezultatele obținute în procesul de elaborare a tezei au fost utilizate pentru instruirea personalului-cheie din Ministerul Finanțelor al Republicii Moldova în aplicarea modelelor de echilibru general pentru evaluarea ex-ante a impactului politicilor fiscale. Modelul a fost utilizat pentru efectuarea unor estimări economice solicitate de Ministerul Economiei și Infrastructurii (impactul socioeconomic al restricțiilor economice cauzate de pandemia COVID-19), Banca Mondială (impactul Zonei de Liber Schimb Aprofundat și Cuprinzător) și ONU (impactul COVID-19 în contextul economiei intergenerațională).

АННОТАЦИЯ

к диссертации на соискание ученой степени доктора экономических наук «Изучение воздействия макроэкономической политики на основе вычислимой модели общего равновесия (на примере Республики Молдова)» Прохницки Валериу, специальность: 521.01. Экономическая теория и экономическая политика, Кишинев, 2021

Структура диссертации: Введение, три основные главы, глава с общими выводами и рекомендациями, библиография, составленная из 116 источников, 14 рисунков, 39 таблиц, 21 табличных приложений. Проведенные исследования отражены в 6 научных публикациях.

Ключевые слова: Общее экономическое равновесие, вычислимая модель общего равновесия с географическим разрешением, Матрица социального учета, национальные счета, оценка воздействия.

Задачи исследования: Разработка согласованной концептуальной основы и адаптация прикладной экономико-математической модели для оценки воздействия макроэкономической политики с акцентом на налоговую, торговую и структурную политику в Республике Молдова.

Задачи исследования: Составление согласованного набора данных в микро-, мезо- и макроэкономическом аспекте; выявление структурных взаимозависимостей в национальной экономике; адаптация количественной модели для оценки вариантов политики; математическая калибровка и эконометрическая оценка параметров модели; моделирование шоков макроэкономической политики и оценка их количественного и распределительного воздействия.

Научная новизна и оригинальность: Углубление теоретических и практических исследований по системной оценке воздействия шоков; тестирование новых способов интеграции регионов и представления структуры принятия решений в общем механизме экономического равновесия; совмещение методов математической калибровки с методами эконометрической оценки структурных параметров и эластичности применяемых моделей общего равновесия.

Результаты, способствующие решению важной научной проблемы: Разработана Матрица социального учета с реальными потоками для национальной экономики; разработана прикладная модель общего равновесия с географическим разрешением (REMMO); выяснено взаимодействие между политикой и реальной экономикой; количественно оценено распределительное влияние макроэкономической политики в региональном аспекте.

Теоретическая значимость: Разработка методологической основы интеграции регионального аспекта в прикладные модели общего равновесия; подробное представление инструментов налогово-бюджетной, торговой и структурной политики; детализация потоков государственного сектора по соответствующим административным уровням; теоретическая интерпретация результатов.

Прикладная ценность: Прикладную модель общего равновесия можно использовать для предварительной оценки воздействия макроэкономической политики на национальную экономику, особенно фискальную, бюджетную, торговую и структурную. Модель также подходит для оценки воздействия внешних шоков, таких как экстремальные природные, технологические или эпидемиологические явления. Матрица социального учета, объединяющая реальный сектор с географической разбивкой, является еще одним результатом, который можно использовать в ряде других приложений.

Внедрение научных результатов: Результаты, полученные в процессе разработки диссертации, были использованы для обучения ключевого персонала Министерства финансов Республики Молдова применению моделей общего равновесия для предварительной оценки воздействия налогово-бюджетной политики. Модель использовалась для проведения экономических оценок, запрошенных Министерством экономики и инфраструктуры (социально-экономические последствия экономических ограничений, вызванных пандемией COVID-19), Всемирным банком (влияние углубленной и всеобъемлющей зоны свободной торговли) и ООН. (влияние COVID-19 в контексте межпоколенческой экономики).

PROHNITCHI VALERIU

IMPACT OF THE MACROECONOMIC POLICIES BASED ON THE COMPUTABLE GENERAL EQUILIBRIUM MODEL (THE CASE OF THE REPUBLIC OF MOLDOVA)

521.01. ECONOMIC THEORY AND ECONOMIC POLICIES

Summary of the doctoral thesis in economics

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