Guide for the BMMX Interregional CGE Model for Mexico Using Customized RunGEM

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1. Introduction

This document explains how to use the Customized RunGEM program to work with the BMMX ICGE model for Mexico. It was originally designed for use at two short courses held in Banco de la República, Cartagena, Colombia, in 2003 and 2015, and a short course at the Policy Center for the New South, in Rabat, Morocco, 2017, and it has been now adapted for use at the workshop "Multi-regional Economic Modeling: Applications for Mexico" to be held in Mexico City in 2020. It draws on the document "Computing Guide for MINIMAL Using Customized RunGEM", by **Mark Horridge**, March 2001.

GEMPACK is a system of software for implementing and solving computable general equilibrium (CGE) models. The BMMX ICGE model is an interregional CGE model, implemented using GEMPACK and designed for policy analysis in Mexico. RunGEM is a windows program that makes it easy for you to run any CGE model created with GEMPACK. Customized RunGEM is a special version of RunGEM that has been hard-wired to work only with one or a few particular models (such as BMMX ICGE). In this document, references to *RunGEM* mean *Customized RunGEM*, tailored for use with the BMMX ICGE model.

This document assumes that you have installed on your computer a recent version of Customized RunGEM (dated March 2001 or later) that contains the BMMX ICGE model. Instructions for doing this are in Appendix 1.

You should also have studied the CoPS working paper OP-85, *The Theoretical Structure of MONASH-MRF*, by Peter *et al*. (1996), the book *Regional Inequality and Structural Changes: Lessons from the Brazilian Economy*, by Haddad (1999), and the article by Haddad and Hewings (2005), *Market Imperfection in a Spatial Economy: Some Experimental Results*, published in the Quarterly Review of Economics and Finance, Vol. 45. They describe the underlying economic theory of the BMMX ICGE model. You should also have studied the NEREUS Working Paper (07-2019), *Interregional Input-Output System for Mexico, 2013*, to familiarize with the structural database of the model.

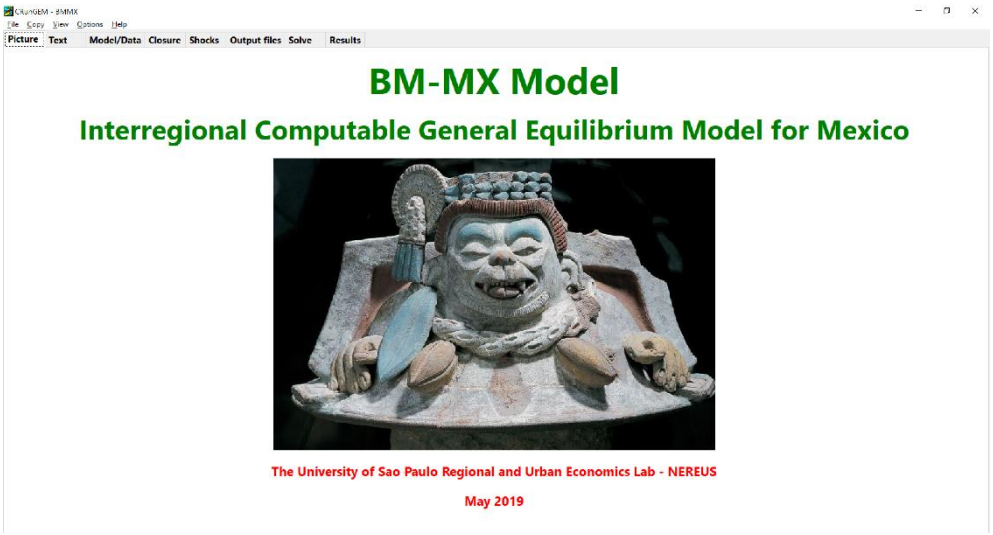
As you read this document, you will use RunGEM to work through examples designed to familiarize you with the software and, perhaps more importantly, the BMMX ICGE model. The instructions are quite detailed. Our aim is to give sufficient detail to enable a new RunGEM user to work through the examples relying solely on this document.

[1] I am grateful to Inácio Araújo who has provided excellent research support.

A series of numbered questions appear throughout the text. Write your answers in the margin.

2. Starting RunGEM

To see RunGEM in action, double-click on the Customized RunGEM (BMMX ICGE Model) icon on your desktop. You should see the following screen:



RunGEM uses a tabbed notebook or card index interface. The first two pages (**Picture** and **Text**) contain general information. The third page (**Model/Data**) contains information about files used by the BMMX ICGE model. The remaining five pages relate to simulations – we explain those in Part 5 below.

The **Help** menu item gives access to extensive online-help about RunGEM. **Customized RunGEM** is a slightly simplified version of RunGEM, so some of the options described there may not apply. There is a special Help menu item, "Customized RunGEM Help", dealing with these differences.

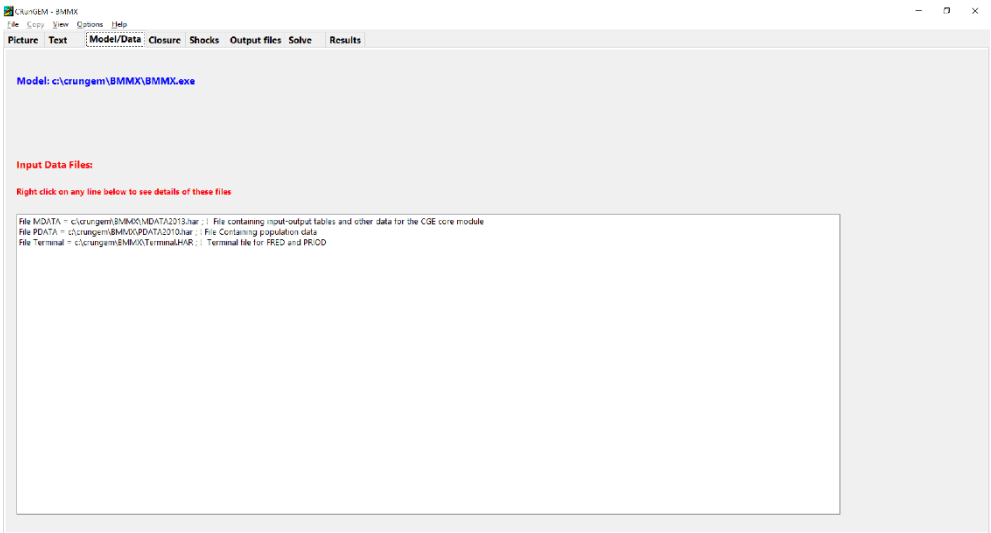
3. The Model/Data page

Have a look at RunGEM's **Model/Data** page. It gives two pieces of information:

- The *model* is BMMX.EXE, an executable program. This has been produced by the GEMPACK program **TABLO** using, as input, the text file BMMX.TAB. To change the model specifications, you need to (a) edit BMMX.TAB, and (b) run TABLO to make BMMX.EXE. That procedure is not covered in this introductory document, and TABLO is not supplied with the **Customized RunGEM** package.

- There are three input data files, MDATA2013.HAR, which corresponds to the logical file

MDATA which is mentioned in BMMX.TAB. Similarly, PDATA2010.HAR corresponds to the logical file, PDATA, and Terminal.HAR to Terminal.



RunGEM and the programs that come with it (TABmate, ViewHAR and others) are parts of the standard GEMPACK system, which allows you to create and modify economic models and data. The customized version of the BMMX ICGE model is designed as an introduction to the BMMX ICGE model itself, using GEMPACK: therefore, the Customized version of RunGEM does not allow you to alter the model equations or database. To change the equations or data, you would need other GEMPACK components (such as the TABLO program) not supplied with Customized RunGEM.

4. Looking at the data

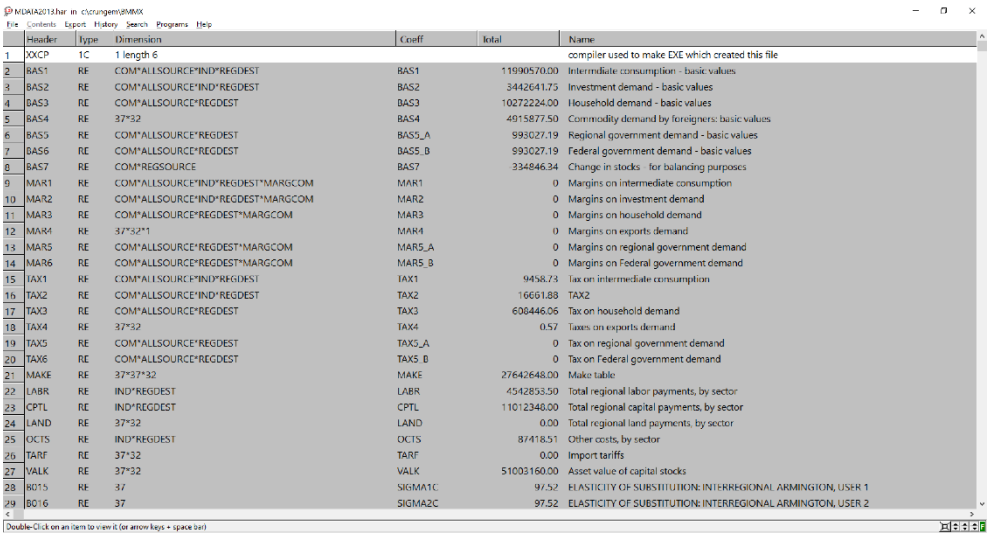
The data files are given the logical names **MDATA**, **PDATA** and **Terminal** in the TAB file **BMMX.TAB** which lays down the theory of BMMX ICGE. To see what information is on the MDATA file, for instance, select

View | Input Data files | Original MDATA

in RunGEM's menu. ["Original MDATA" appears to the side of "Input Data files"].

This will start up **ViewHAR,** a windows program for viewing and modifying data held in GEMPACK Header Array files. It will open the MDATA file and show a Contents screen.[2]

[2] The top of the ViewHAR window shows the actual name (MDATA2013.HAR) and location of the file which has logical name MDATA in the TAB file.



MDATA2013.har in c:\crungem\BMMX

File Contents Export History Search Programs Help

	Header	Type	Dimension	Coeff	Total	Name
1	XXCP	1C	1 length 6			compiler used to make EXE which created this file
2	BAS1	RE	COM*ALLSOURCE*IND*REGDEST	BAS1	11990570.00	Intermediate consumption - basic values
3	BAS2	RE	COM*ALLSOURCE*IND*REGDEST	BAS2	3442641.75	Investment demand - basic values
4	BAS3	RE	COM*ALLSOURCE*REGDEST	BAS3	10272224.00	Household demand - basic values
5	BAS4	RE	37*32	BAS4	4915877.50	Commodity demand by foreigners: basic values
6	BAS5	RE	COM*ALLSOURCE*REGDEST	BAS5_A	993027.19	Regional government demand - basic values
7	BAS6	RE	COM*ALLSOURCE*REGDEST	BAS5_B	993027.19	Federal government demand - basic values
8	BAS7	RE	COM*REGSOURCE	BAS7	334846.34	Change in stocks for balancing purposes
9	MAR1	RE	COM*ALLSOURCE*IND*REGDEST*MARGCOM	MAR1	0	Margins on intermediate consumption
10	MAR2	RE	COM*ALLSOURCE*IND*REGDEST*MARGCOM	MAR2	0	Margins on investment demand
11	MAR3	RE	COM*ALLSOURCE*REGDEST*MARGCOM	MAR3	0	Margins on household demand
12	MAR4	RE	37*32*1	MAR4	0	Margins on exports demand
13	MAR5	RE	COM*ALLSOURCE*REGDEST*MARGCOM	MAR5_A	0	Margins on regional government demand
14	MAR6	RE	COM*ALLSOURCE*REGDEST*MARGCOM	MAR5_B	0	Margins on Federal government demand
15	TAX1	RE	COM*ALLSOURCE*IND*REGDEST	TAX1	9458.73	Tax on intermediate consumption
16	TAX2	RE	COM*ALLSOURCE*IND*REGDEST	TAX2	16661.88	TAX2
17	TAX3	RE	COM*ALLSOURCE*REGDEST	TAX3	608446.06	Tax on household demand
18	TAX4	RE	37*32	TAX4	0.57	Taxes on exports demand
19	TAX5	RE	COM*ALLSOURCE*REGDEST	TAX5_A	0	Tax on regional government demand
20	TAX6	RE	COM*ALLSOURCE*REGDEST	TAX5_B	0	Tax on Federal government demand
21	MAKE	RE	37*37*32	MAKE	27642648.00	Make table
22	LABR	RE	IND*REGDEST	LABR	4542853.50	Total regional labor payments, by sector
23	CPTL	RE	IND*REGDEST	CPTL	11012348.00	Total regional capital payments, by sector
24	LAND	RE	37*32	LAND	0.00	Total regional land payments, by sector
25	OCTS	RE	IND*REGDEST	OCTS	87418.51	Other costs, by sector
26	TARF	RE	37*32	TARF	0.00	Import tariffs
27	VALK	RE	37*32	VALK	51003160.00	Asset value of capital stocks
28	B015	RE	37	SIGMA1C	97.52	ELASTICITY OF SUBSTITUTION: INTERREGIONAL ARMINGTON, USER 1
29	B016	RE	37	SIGMA2C	97.52	ELASTICITY OF SUBSTITUTION: INTERREGIONAL ARMINGTON, USER 2

Double-Click on an item to view it (or arrow keys + space bar)

Each of the rows corresponds to a different array of data on the file. Look at the **Name** column to see what these arrays are.[3] Use the buttons at bottom right to set your preferred font size.

You can see that array number 22 is the data at Header "LABR". The data at this header is the value of labor payments, measured in millions of 2013 Mexican Pesos (MXN). To see the actual data, double-click on the LABR row.

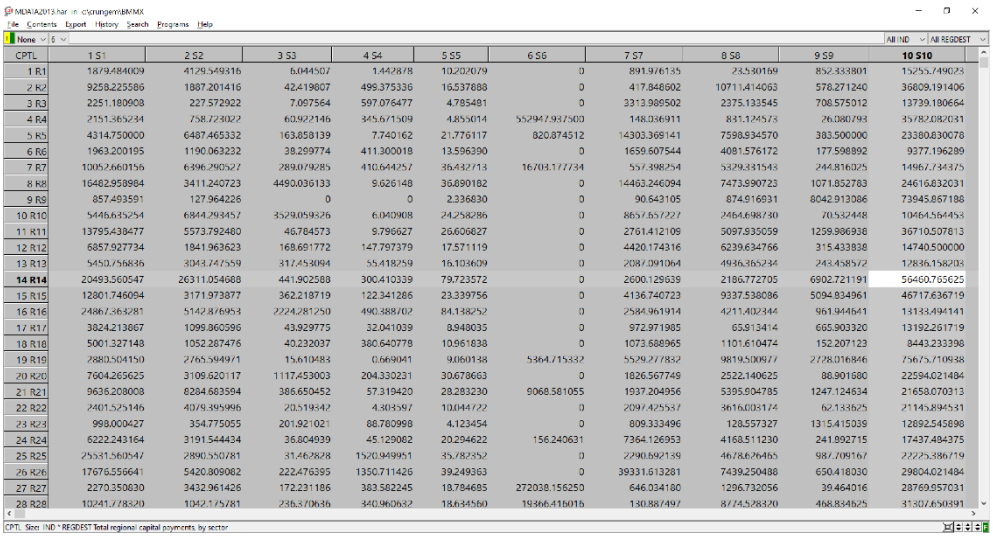
Q1. What is the value of wages in textile industry (S13) in Puebla (R21)?

Now click on ***Contents*** in ViewHAR's main menu to return to the list of contents. Similarly, the array number 23 is the data at Header "CPTL". The data at this header is the value of capital payments, measured in millions of 2013 MXN. To see the actual data, double-click on the CPTL row.

Q2. What is the value of capital payments in the construction sector (S10) in Jalisco (R14)?

Click on the small yellow rectangle near the top left of the ViewHAR window to transpose the matrix (exchange rows and columns). This makes it easier to see.

[3] The arrays may be ordered differently from the list in the text. You can set ViewHAR up to either list the headers alphabetically, or to list them in the order they were written to file. ViewHAR's **File…Options** menu command can be used to customize the display in various ways.



MDATA2013.har in c:\ctrungem\BMMX

File Contents Export History Search Programs Help

None 6 All IND All REGDEST

CPTL	1 S1	2 S2	3 S3	4 S4	5 S5	6 S6	7 S7	8 S8	9 S9	10 S10
1 R1	1879.484009	4129.549316	6.044507	1.442878	10.202079	0	891.976135	23.530169	852.333801	15255.749023
2 R2	9258.225586	1887.201416	42.419807	499.375336	16.537888	0	417.848602	10711.414063	578.271240	36809.191406
3 R3	2251.180908	227.572922	7.097564	597.076477	4.785481	0	3313.988502	2375.133545	708.575012	13739.180664
4 R4	2151.365234	758.723022	60.922146	345.671509	4.855014	552947.937500	148.036911	831.124573	26.080793	35782.082031
5 R5	4314.750000	6487.465332	163.858139	7.740162	21.776117	820.874512	14303.369141	7598.934570	383.500000	23380.830078
6 R6	1963.200195	1190.063232	38.299774	411.300018	13.596390	0	1659.607544	4081.576172	177.598892	9377.196289
7 R7	10052.660156	6396.290527	289.079285	410.644257	36.432713	16703.177734	557.398254	5329.331543	244.816025	14967.734375
8 R8	16482.958984	3411.240723	4490.036133	9.626148	36.690182	0	14463.246094	7473.590723	1071.852783	24616.832031
9 R9	857.493591	127.964226	0	0	2.336830	0	90.643105	874.916931	8042.913086	73945.867188
10 R10	5446.635254	6844.293457	3529.059326	6.040908	24.258286	0	8657.657227	2464.698730	70.532448	10464.564453
11 R11	13795.438477	5573.792480	46.784573	9.796627	26.606827	0	2761.412109	5097.935059	1259.986938	36710.507813
12 R12	6857.927734	1841.963623	168.691772	147.797379	17.571119	0	4420.174316	6239.634766	315.433838	14740.500000
13 R13	5450.756836	3083.747559	317.453094	55.418259	16.103609	0	2087.091064	4936.365234	243.458572	12836.158203
14 R14	20493.560547	26311.054688	441.902588	300.410339	79.723572	0	2600.129639	2186.772705	6902.721191	56460.765625
15 R15	12801.746094	3171.973877	362.218719	122.341286	23.339756	0	4136.740723	9337.538086	5094.834961	46717.636719
16 R16	24867.363281	5142.876953	2224.281250	490.388702	84.138252	0	2584.961914	4211.402344	961.944641	13133.494141
17 R17	3824.213867	1099.860596	43.929775	32.041039	8.948035	0	972.971985	65.913414	665.903320	13192.261719
18 R18	5001.327148	1052.287476	40.232037	380.640778	10.961838	0	1073.688965	1101.610474	152.207123	8443.233398
19 R19	2880.504150	2765.594971	15.610483	0.669041	9.080138	5364.715332	5529.277832	9819.500977	2728.016846	75675.710938
20 R20	7604.265625	3109.620117	1117.453003	204.330231	30.678663	0	1826.567749	2522.140625	88.901680	22594.021484
21 R21	9636.208008	6284.683594	386.650452	57.319420	28.283230	9068.581055	1937.204956	5395.904785	1247.124634	21658.070313
22 R22	2401.525146	4079.395996	20.519342	4.803597	10.044722	0	2097.425537	3616.008174	62.133625	21145.894531
23 R23	998.000427	354.775055	201.921021	88.780998	4.123454	0	809.333496	128.557327	1315.415039	12892.545898
24 R24	6222.243164	3191.544434	36.804939	45.129062	20.294622	156.240631	7364.126953	4168.511230	241.892715	17437.484375
25 R25	25531.560547	2890.550781	31.462828	1520.949951	35.782352	0	2290.692139	4678.626465	987.709167	22225.386719
26 R26	17676.556641	5420.809082	222.476395	1350.711426	39.249363	0	39331.613281	7439.250488	650.418030	29804.021484
27 R27	2270.350830	3432.961426	172.231186	383.582245	18.784685	272038.156250	646.034180	1296.732056	39.464016	28769.957031
28 R28	10241.778320	1042.175781	236.370646	340.960632	18.634560	19366.416016	130.887497	8724.528320	468.834625	31307.650391

CPTL Size: IND * REGDEST Total regional capital payments, by sector

ViewHAR is able to show you some shares, as well as the actual data. To see this, click the drop-down list boxes near the top left-hand corner of the ViewHAR window, which at present probably says **None** [we call it the **shares list box**]. Select the **row** share.

Q3. What is Sinaloa's (R25) share in capital payments to food industry (S11)?

Q4. And in agriculture (S1)?

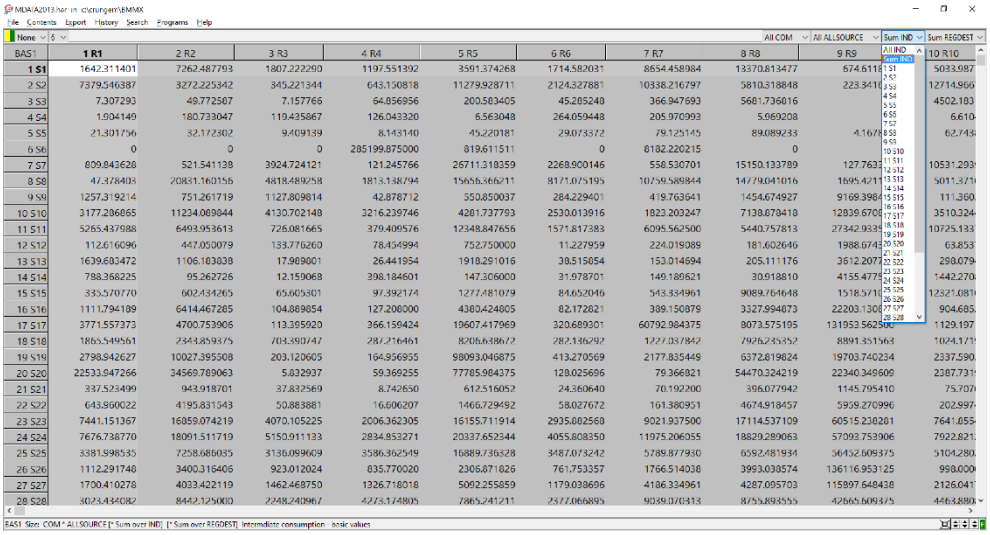
Q5. What is Sinaloa's share in the economy-wide payments to capital?

Q6. In which region the agriculture sector is responsible for the highest shares of labor payments?

Q7. Which sector is most capital-intensive in Mexico?

Shares like these are often useful for explaining simulation results.

Now click again on ***Contents*** in ViewHAR's main menu to return to the list of contents. Look at the BAS1 row (array number 2). You can see that this is a 4-dimensional array of size **COMxALLSOURCExINDxREGDEST**. The data at this header is the basic value of commodity inputs to the production process, also measured in millions of 2013 MXN. To see the actual data, double-click on this BAS1 row. You see a 37x33 matrix of data (plus a totals row and a totals column); the rows have commodity labels and the columns are labelled "R1" up to "R32" plus a 33rd column labelled "FOR". These must be the elements of the sets COM (commodities) and ALLSOURCE (source), respectively. What about the 3rd dimension IND and the 4th dimension REGDEST of this data array? The clue is given by the 4 drop-down lists near the top right-hand corner of the screen which say **All COM; All ALLSOURCE; Sum IND; Sum REGDEST** respectively. Because your computer screen is 2-dimensional, what you are seeing are the IND and REGDEST values **summed across sectors and regions**.



BAS1	1 R1	2 R2	3 R3	4 R4	5 R5	6 R6	7 R7	8 R8	9 R9	10 R10
1 S1	1642.311401	7262.487793	1807.222290	1197.551392	3591.374268	1714.582031	8654.458984	13370.813477	674.611	5033.987
2 S2	7379.546387	3272.225342	345.221344	643.150818	11279.928711	2124.327881	10338.216797	5810.318848	223.341	12714.966
3 S3	7.307293	49.772587	7.157766	64.856956	200.563405	45.285248	366.947593	5681.736016		4502.103
4 S4	1.904149	180.733047	119.435867	126.043320	6.563048	264.059448	205.970993	5.969208		6.610
5 S5	21.301756	32.172302	9.409139	8.143140	45.220181	29.073372	79.125145	89.089233	4.167	62.743
6 S6	0	0	0	285199.875000	819.611511	0	8182.220215	0		
7 S7	809.843628	521.541138	3924.724121	121.245766	26711.318359	2268.900146	558.530701	15150.133789	127.763	10531.293
8 S8	47.378403	20831.160156	4818.489258	1813.138794	15656.366211	8171.075195	10759.589844	14779.041016	1695.421	5011.371
9 S9	1257.319214	751.261719	1127.809814	42.878712	550.850037	284.229401	419.763641	1454.674927	9169.398	111.360
10 S10	3177.286865	11234.089844	4130.702148	3216.239746	4281.737793	2530.013916	1823.203247	7138.678418	12839.670	3510.324
11 S11	5265.437988	6493.953613	726.081665	379.409576	12348.847656	1571.817383	6095.562500	5440.757813	27342.933	10725.133
12 S12	112.616096	447.050079	133.776260	78.454994	752.750000	11.227959	224.019089	181.602646	1988.674	63.853
13 S13	1639.683472	1106.183038	17.969001	26.441954	1918.291016	38.515054	153.014694	205.111176	3612.207	298.079
14 S14	788.368225	95.262726	12.159068	398.184601	147.306000	31.978701	149.189621	30.918810	4155.477	1442.270
15 S15	335.570770	602.434265	65.605301	97.392174	1277.481079	84.652046	543.334961	9089.764648	1518.571	12321.081
16 S16	1111.794189	6414.467285	104.889854	127.206000	4380.424805	82.172821	389.150879	3327.994873	22203.130	904.685
17 S17	3771.557373	4700.753906	113.395920	366.159424	19607.417969	320.689301	60792.984375	8073.575195	131953.562500	1129.197
18 S18	1865.549561	2343.859375	703.390747	287.216461	8206.638672	282.136292	1227.037842	7926.235352	8891.351563	1024.171
19 S19	2798.942627	10027.395508	203.120605	164.956955	98093.046875	413.270569	2177.835449	6372.819824	19703.740234	2337.590
20 S20	22533.947266	34569.789063	5.832937	59.369255	77785.984375	128.025696	79.366821	54470.324219	22340.349609	2387.731
21 S21	337.523499	943.918701	37.832569	8.742650	612.516052	24.360640	70.192200	396.077942	1145.795410	75.707
22 S22	643.960022	4195.831543	50.883881	16.606207	1466.729492	58.027672	161.380951	4674.918457	5959.270996	202.997
23 S23	7441.151367	16859.074219	4070.105225	2006.362305	16155.711914	2935.682568	9021.937500	17114.537109	60515.238281	7641.055
24 S24	7676.738770	18091.511719	5150.911133	2834.853271	20337.652344	4055.808350	11975.206055	18829.289063	57093.753906	7922.821
25 S25	3381.998535	7258.686035	3136.059609	3586.362549	16889.736328	3487.073242	5789.877930	6592.481934	56452.609375	5104.280
26 S26	1112.291748	3400.316406	923.012024	835.770020	2306.871826	761.753357	1766.514038	3993.038574	136116.953125	998.000
27 S27	1700.410278	4033.422119	1462.468750	1326.718018	5092.255859	1179.038696	4186.334961	4287.095703	115897.648438	2126.041
28 S28	3023.434082	8442.125000	2248.240967	4273.174805	7865.241211	2377.066895	9039.070313	8755.893555	42665.609375	4463.880

Q8. What is the total across all sectors of the value of professional, scientific and technical services (S29) produced in Ciudad de Mexico (R9) and sold in Campeche (R4) and Coahuila de Zaragoza (R5)?

Q9. What is the total across all sectors and across all regions of the value of imported manufactured inputs (S11-S22)?

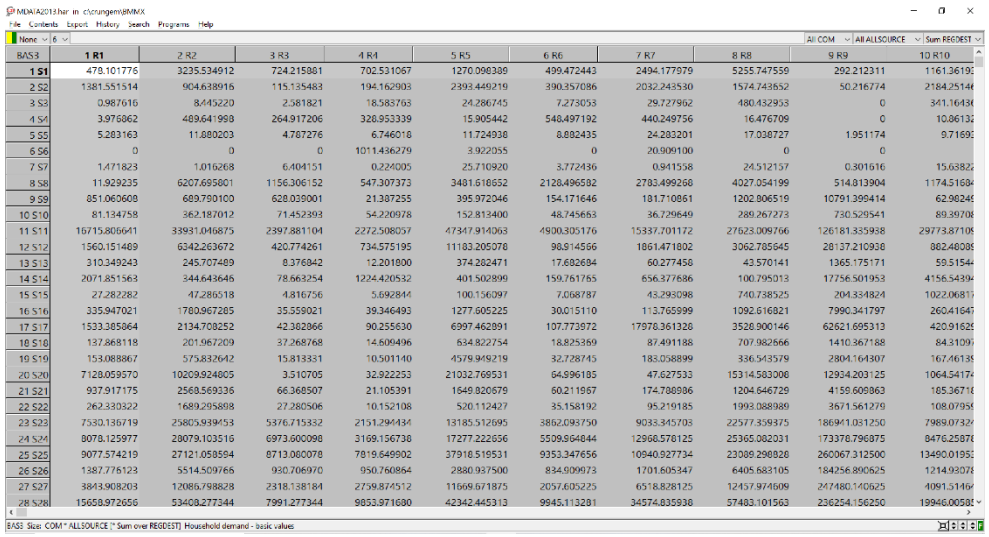
How can you see the value of purchases of one specific input (say machinery, S20) by just one sector, for example, other manufacturing (S22), in a given location (e.g. Chihuahua, R8)? To see this, click on the **All COM** drop-down list box near the top right-hand side and select "S20" from the options. Then, click on the **All IND** drop-down list box and select "S22" from the options. Finally, select "R8" from the drop-down list **All REGDEST**. The data will change and now you are seeing how much is purchased just of machinery inputs by the other manufacturing sector in Chihuahua.

Q10. How much imported machinery inputs (S20) is purchased in Chihuahua (R5) by the other manufacturing sector (S17)?

Q11. What are the three main sources of oil inputs (S6) to the oil, chemical and parachemical industry (S17) in Veracruz (R30)?

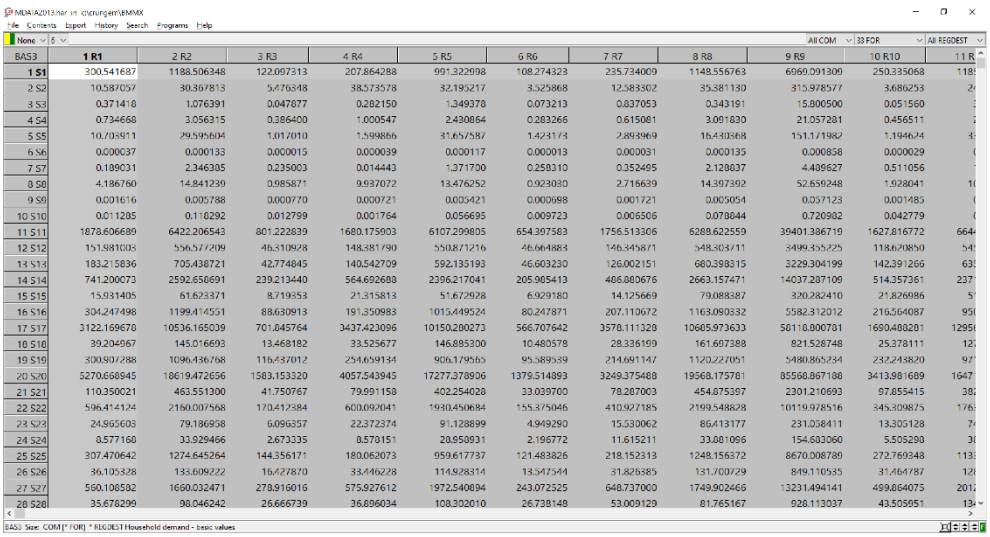
Q12. And the three main sources of agricultural inputs (S1) to Durango's (R10) food industry (S11) and beverage and tobacco sectors (S12)?

Now click again on ***Contents*** in ViewHAR's main menu to return to the list of contents. Look at the rows BAS2, BAS3, BAS4, BAS5, BAS6 and BAS7. They represent commodity demands by the other users in the BMMX ICGE model, namely, investors, households, foreigners, regional government, Federal government, and changing in stocks. Let us look at household demand (BAS3). You can see that this is a 3-dimensional array of size **COMxALLSOURCExREGDEST**. There are many ways of viewing 2-dimensional slices of a multi-dimensional array.



BAS3	1 R1	2 R2	3 R3	4 R4	5 R5	6 R6	7 R7	8 R8	9 R9	10 R10
1 S1	478.101776	3235.534912	724.215881	702.531067	1270.096389	499.472443	2494.177979	5255.747559	292.212311	1161.36193
2 S2	1381.551514	904.638916	115.135483	194.162903	2393.449219	390.357086	2032.243530	1574.743652	50.216774	2184.25146
3 S3	0.987616	8.445220	2.581821	18.583763	24.286745	7.273053	29.727962	480.432953	0	341.16436
4 S4	3.976862	489.641998	264.917206	328.953339	15.905442	548.497192	440.249756	16.476709	0	10.86132
5 S5	5.283163	11.880203	4.787276	6.746018	11.724938	8.882435	24.283201	17.038727	1.951174	9.71695
6 S6	0	0	0	101.436279	3.922055	0	20.909100	0	0	
7 S7	1.471823	1.016268	6.404151	0.224005	25.710920	3.772436	0.941558	24.512157	0.301616	15.63822
8 S8	11.929235	6207.695801	1156.306152	547.307373	3481.618652	2128.496582	2783.499268	4027.054199	514.813904	1174.51684
9 S9	851.060608	689.790100	628.039001	21.387255	395.972046	154.171646	181.710861	1202.806519	10791.399414	62.98245
10 S10	81.134758	362.187012	71.452393	54.220978	152.813400	48.745663	36.729649	289.267273	730.529541	89.39708
11 S11	16715.806641	33931.046875	2397.881104	2272.508057	47347.914063	4900.305176	15337.701172	27623.009766	126181.335938	29773.87109
12 S12	1560.151489	6342.263672	420.774261	734.575195	11183.205078	968.914566	1861.471802	3062.785645	28137.210938	882.48009
13 S13	310.349243	245.707489	8.376842	12.201800	374.282471	17.682684	60.277458	43.570141	1365.175171	59.51544
14 S14	2071.851563	344.643646	78.663254	1224.420532	401.502899	159.761765	656.377686	100.795013	17756.501953	4156.54394
15 S15	27.282282	47.286518	4.816756	5.692844	100.156097	7.068787	43.293098	740.738525	204.334824	1022.06817
16 S16	335.947021	1780.967285	35.559021	39.346493	1277.605225	30.015110	113.765999	1092.616821	7990.341797	260.41647
17 S17	1533.385864	2134.708252	42.362866	90.255630	6997.462891	107.773972	17976.361328	3528.900146	62621.695313	420.91629
18 S18	137.868118	201.967209	37.268768	14.609496	634.822754	18.825369	87.491188	707.982666	1410.367188	84.3109
19 S19	153.088867	575.832642	15.813331	10.501140	4579.949219	32.728745	183.058899	336.543579	2804.164307	167.46139
20 S20	7128.059570	10209.924805	3.510705	32.922253	21032.769531	64.996185	47.627533	15314.583008	12934.203125	1064.54174
21 S21	937.917175	2568.569336	66.368507	21.105391	1649.820679	60.211967	174.788986	1204.646729	4159.609863	185.36718
22 S22	262.330322	1689.295898	27.280506	10.152108	520.112427	35.158192	95.219185	1993.088989	3671.561279	108.07959
23 S23	7530.136719	25805.939453	5376.715332	2151.294434	13185.512695	3862.093750	9033.345703	22577.359375	186941.031250	7989.07324
24 S24	8078.125977	28079.103516	6973.600098	3169.156738	17277.222656	5509.964844	12968.578125	25365.082031	173378.796875	8476.25878
25 S25	9077.574219	27121.058594	8713.080078	7819.649902	37918.519531	9353.347656	10940.927734	23089.298828	260067.312500	13490.01953
26 S26	1387.776123	5514.509766	930.706970	950.760864	2880.937500	834.909973	1701.605347	6405.683105	184256.890625	1214.93078
27 S27	3843.908203	12086.798828	2318.138184	2759.874512	11669.671875	2057.605225	6518.828125	12457.974609	247480.140625	4091.51464
28 S28	15658.972656	53408.277344	7991.277344	9853.971680	42342.445313	9945.113281	34574.835938	57483.101563	236254.156250	19946.00585

To see another, click on the **ALLSOURCE** drop-down list box (the 2nd of the three) and select **FOR** so that only foreign purchases are shown. Now click on the 3rd, **REGDEST**, list box and select **All REGDEST**.



BAS3	1 R1	2 R2	3 R3	4 R4	5 R5	6 R6	7 R7	8 R8	9 R9	10 R10	11 R
1 S1	300.541687	1188.506348	122.097213	207.864288	991.322998	108.274323	235.734009	1148.556763	6969.091309	250.335068	118
2 S2	10.587057	30.367813	5.476348	38.573578	32.195217	3.525868	12.583302	35.381130	315.978577	3.680253	2
3 S3	0.371418	1.076391	0.047677	0.282150	1.349378	0.073213	0.837053	0.343191	15.800500	0.051560	3
4 S4	0.734668	3.056315	0.386400	1.000547	2.430864	0.283266	0.615081	3.091830	21.057281	0.456511	2
5 S5	10.703911	29.595604	1.017010	1.599866	31.657587	1.423173	2.893969	16.430368	151.171982	1.194624	3
6 S6	0.000037	0.000133	0.000015	0.000039	0.000117	0.000013	0.000031	0.000135	0.000858	0.000029	0
7 S7	0.189031	2.346305	0.235003	0.014443	1.371700	0.250310	0.352495	2.128037	4.489627	0.511056	1
8 S8	4.186760	14.841239	0.985871	9.937072	13.476252	0.923030	2.716639	14.397392	52.659248	1.928041	1
9 S9	0.001616	0.005788	0.000770	0.000721	0.005421	0.000698	0.001721	0.005054	0.057123	0.001485	0
10 S10	0.011285	0.118292	0.012799	0.001764	0.056695	0.009723	0.006506	0.078044	0.720982	0.042779	0
11 S11	1878.606689	6422.206543	801.222839	1680.175903	6107.299805	654.397583	1756.513306	6288.622559	39401.386719	1627.816772	664
12 S12	151.981003	556.577209	46.310928	148.381790	550.871216	46.664883	146.345871	548.303711	3499.355225	118.620850	54
13 S13	183.215836	705.438721	42.774845	140.542709	592.135193	46.603230	126.002151	680.398315	3229.304199	142.391266	63
14 S14	741.200073	2592.658691	239.213440	564.692688	2396.217041	205.985413	486.880676	2663.157471	14037.287109	514.357361	237
15 S15	15.931405	61.623371	8.719853	21.315813	51.672928	6.929180	14.125669	79.088387	320.282410	21.826986	5
16 S16	304.247498	1199.414551	88.630913	191.350983	1015.449524	80.247871	207.110672	1163.090332	5582.312012	216.564087	95
17 S17	3122.169678	10536.165039	701.045764	3437.423096	10150.200273	566.707642	3578.111328	10605.973633	50110.000781	1690.480201	1295
18 S18	39.204967	145.016693	13.468182	33.525677	146.885300	10.480578	28.336199	161.697388	821.528748	25.378111	12
19 S19	300.807288	1096.436768	116.437012	254.659134	906.179565	95.589539	214.691147	1120.227051	5480.865234	232.243820	97
20 S20	5270.668945	18619.472656	1583.153320	4057.543945	17277.378906	1379.514893	3249.375488	19568.175781	85568.867188	3413.981689	1647
21 S21	110.350021	463.551300	41.750767	79.991158	402.254028	33.039700	78.287003	454.875397	2301.210693	97.855415	38
22 S22	596.414124	2160.007568	170.412284	600.092041	1930.450684	155.375046	410.927185	2199.548828	10119.978516	345.309875	176
23 S23	24.965603	79.186958	6.096357	22.372374	91.128899	4.949290	15.530062	86.413177	231.058411	13.305128	7
24 S24	0.577160	33.929466	2.673335	0.570151	20.950931	2.196772	11.615211	33.081096	154.603060	5.505290	3
25 S25	307.470642	1274.645264	144.356171	180.062073	959.617737	121.483826	218.152313	1248.156372	8670.008789	272.769348	113
26 S26	36.105328	133.609222	16.427870	33.446228	114.928314	13.547544	31.826385	131.700729	849.110535	31.464787	12
27 S27	560.108592	1660.032471	278.916016	575.927612	1972.540894	243.072525	648.737000	1749.902466	13231.494141	499.864075	201
28 S28	35.678299	98.046242	26.666739	36.896034	108.302010	26.738148	53.009129	81.765167	928.113037	43.505951	13

Q13. What is the value of imported agriculture goods (S1) consumed by households in Yucatán (R31)?

Q14. What is the total value of imported manufactured goods (S11-S22) consumed by Mexican households?

Let's look now at the structure of household consumption embedded in the model. First, click on the **ALLSOURCE** drop-down list box and select **Sum ALLSOURCE**, so that only total purchases are shown. Click on the **REGDEST** drop-down list box and select **ALLREGDEST**.

Click on the small yellow rectangle near the top left of the ViewHAR window to transpose the matrix (exchange rows and columns). From the shares list box, select **row** shares. Now you are seeing consumption shares.

Q15. What do you notice about regional structure of consumption?

Q16. What commodity is responsible for the highest share of household expenses in Mexico?

We saw that all regions have the same structure of consumption. This is a hypothesis used to construct the database of the BMMX ICGE model (see Haddad et al., 2019). However, the model allows for different structures of regional dependence on suppliers. Let's check it!

Q17. What share of household consumption of agricultural goods (S1) in Sinaloa (R25) is supplied by producers within the region? And what is the share of agricultural products consumed by households in Ciudad de Mexico (R9) is supplied locally?

In the theoretical specification of the BMMX ICGE model, domestic output is directed to sales to intermediate use (BAS1), capital creation (BAS2), household consumption (BAS3), exports (BAS4), regional governments (BAS5), and sales to the Federal government (BAS6). There is also a final user associated with changes in stocks (BAS7). In addition, the structure of the model allows transport (S25) to be consumed also as a margin-commodity, used to facilitate transactions between origin-destination pairs. Total sales for margin usage, by different users, are found in the arrays MAR1, MAR2, MAR3, MAR 4, MAR5 and MAR6. Notice that there is no margin consumption associated with changes in stocks. Notice also that the values for all margins are "zeroed" in the current calibration of the model.

To answer the following questions, you may use Excel to help you. You can easily copy from ViewHAR and paste to Excel. Note in the main menu that you can decide whether or not to export details from the arrays [***Export* |*Options (labels, totals)***].

Q18. Which sector has the highest export share in the country?

Q19. Which sector sells the greatest proportion of its output to households?

Q20. And which is the most investment-oriented in its sales pattern?

Q21. What is the total output of transport (S25)? (You would have to add margin sales in case part of the output of the transport sector had been allocated to margin usage!)

Q22. If exports of agriculture goods (S1) increased by 10%, what would be the expected percent increase in agriculture output (assuming other sales unchanged)?

Q23. What might happen to oil output (S6) if its exports went up 10%?

Just to refresh, answer the following:

Q24. Which sector uses the greatest proportion of imports in its material inputs?

Q25. And which final demander (no need to include margins)?

User	*Import share*
Investors	
Households	
Exports	
Regional government	
Federal government	

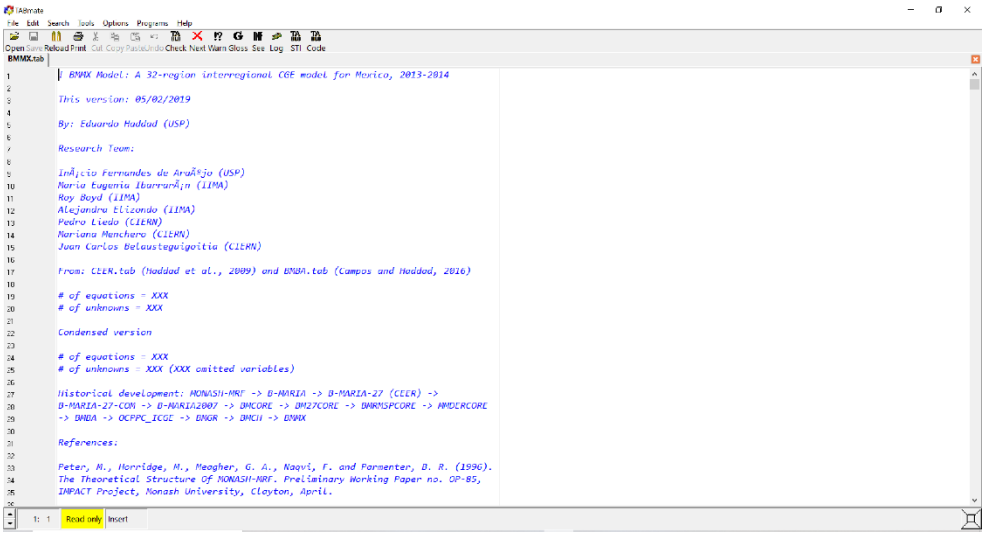
Now close the ViewHAR window by selecting ***File | Exit*** from ViewHAR's (not RunGEM's) menu.

Binary files (such as Header Array files) cannot be looked at in a text editor. To see this, select ***View | Other Text File*** from RunGEM's main menu and select MDATA2013.HAR (the data file). RunGEM tells you that it is unable to open this as a text file (and even suggests that you try to open it with ViewHAR).

5. Looking at the TAB file[4]

To see the model equations use the **View** menu item at the top of the **RunGEM** window and select

View | Main TABLO file



[4] The term **TAB file** is shorthand for **TABLO input file**.

A text editor will appear, with the file BMMX.TAB visible. This will probably be the TABmate editor used by GEMPACK. It will be in read-only mode so that you cannot change the TAB file. The TAB file uses the TABLO language to specify the equations and variables of the BMMX model.

TABmate colours items in the TAB file according to their function:

- black for words that are part of the TABLO language;
- green for variables and other items that are specific to this model;
- blue for comments which GEMPACK ignores;
- *italics* for strings that GEMPACK uses as labels or descriptions.

You might also see line numbers in the left-hand margin.

Now search for MDATA. Select ***Search | Find...*** from the editor's menu, type in "MDATA", and click **OK** (or press Enter). To search again after you have found the first occurrence, you can either again click OK, or you can close the Search dialog and touch the **F3** key (near the top of your keyboard). Close the Search dialog and press **F3** to see the first 3-4 occurrences of MDATA. You will see that various pieces of data are read from this file. [Note: where several **Read** statements occur together, the keyword "Read" is only needed for the first Read statement in the group.]

Click on the word MDATA, then click the button above marked **Gloss**. A window will appear, showing each line that contains that word. Line numbers appear in red – you can click on these red numbers to go to that line. Click to go to the line where **LAB_OCC_IND** is read from file.

You will see that the matrix LAB_OCC_IND is read from the header "LABR". The **header** is a short key (up to 4 letters) which identifies the location of LAB_OCC_IND, within the MDATA file (in fact you previously used ViewHAR to examine the values of LAB_OCC_IND in that file). Now click on the word LAB_OCC_IND, then again click the **Gloss** button to see all occurrences of it. You will see that LAB_OCC_IND is declared as a **COEFFICIENT** and that it holds the value of labor payments. It is used in numerous equations and formulae. Click on the line number for equation E_p0a (zero pure profits in current production) to go there. Click on the word "Equation" and press **Gloss** again. This time you get a list defining all the variables and coefficients in the equation. Press spacebar to close the Gloss window.

You have learned two ways to use the **Gloss** button:

- click on a variable, coefficient or filename: **Gloss** shows every occurrence of that symbol;
- click elsewhere in a statement: **Gloss** shows the first occurrence of each symbol used there.

Both techniques can be very useful to find your way about the TAB file.

Now close TABmate (click the X button at top right of window) and return to RunGEM

6. Running a *numéraire* simulation

In this simulation, the usual *numéraire*, **natphi** (the exchange rate), is increased by 10 per cent.

For simulations, the last pages **Closure - Shocks - Output files - Solve - Results** are usually accessed in that order (from left to right).

First, click on the **Closure** page of RunGEM. You will see a list of the exogenous variables in the currently selected closure. You can choose between several different closures when running a simulation. The panel below shows which variables are exogenous in the selected closure. RunGEM allows you to load different closures already prepared.[5] To see this, use the **Load Closure** button to load the **short run** closure file (BMMX.cls). Notice that **natphi** is one of the exogenous variables.

Now go to the **Shocks** page. Click on the **Clear Shocks List** button to remove whatever shocks are shown. Now you will specify a shock to variable **natphi**. To do this, click on the **down arrow** to the right of the label **Variable to shock** near the top of the Shocks page. A drop-down list of all the exogenous variables in this standard closure will appear. Click on **natphi**. A new edit box entitled **Value of Shock** will appear. Click in this and type in **10**. Then click on the button **Add to Shock List**. The line

Shock natphi = 10;

should appear in the Shocks memo which occupies the bottom half of the Shocks page. This is the only shock for the *numéraire* simulation.

Have a look at the **Output files** page. It controls the names of output files produced by the simulation. Don't change anything now. Go to the **Solve** page of RunGEM.

1 First, click on the topmost **Change** button (the one with **Solution method** before it). Click on **Johansen** to select Johansen's method. You will learn more about the different solution methods available later in this document.

2 If it is not already there, insert the text **Numéraire simulation** in the text box labelled **Verbal description**.

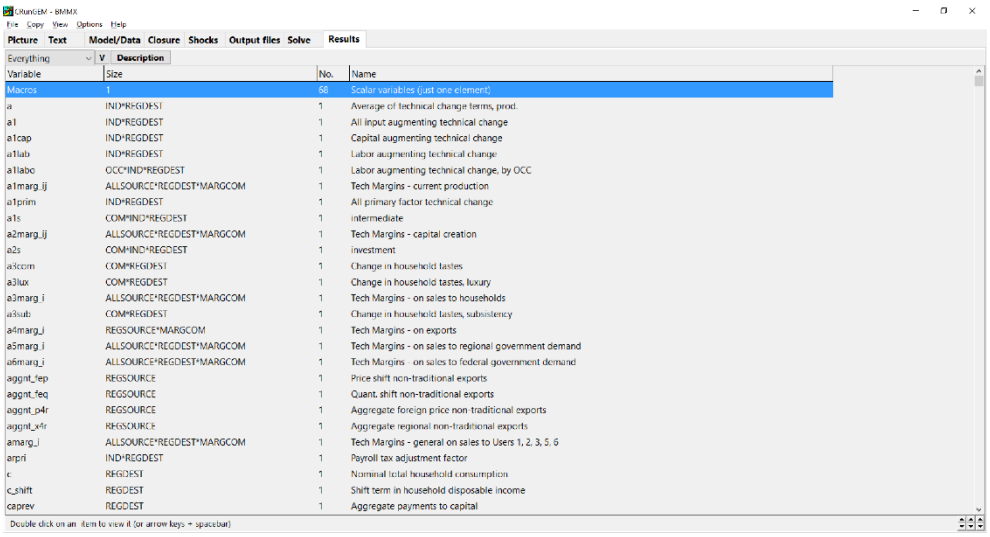
3 Now click on the **Solve** button. A "Please Wait" window will appear while the model is solved. Then RunGEM will show you a box telling you how long the solution took. Just press OK.

The next natural step is to look at the results.

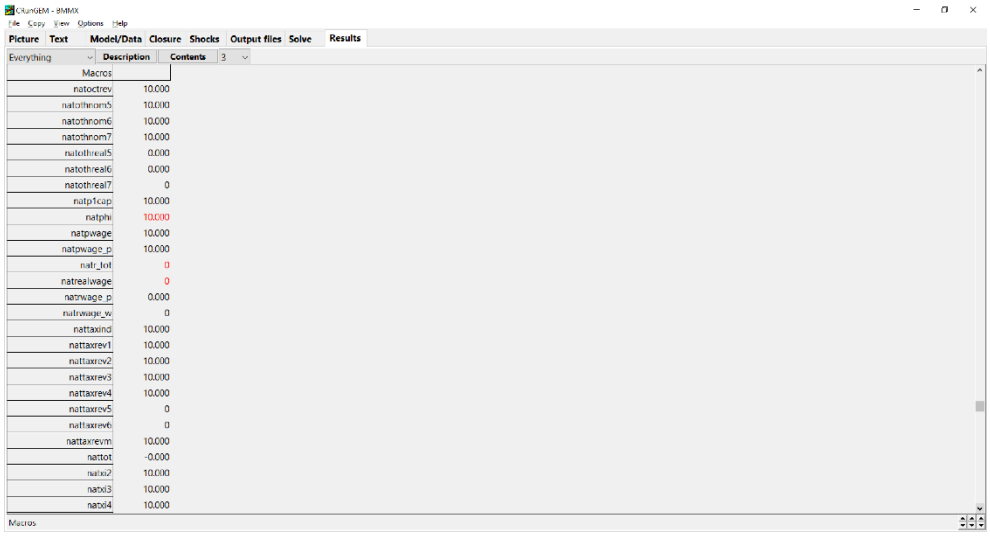
[5] You can also edit the closure shown on the Closure page, and can save this edited closure.

7. Looking at the results

Click on the Results page of RunGEM. This page allows you to inspect the variable values computed during the **last** successful solution process. You will see the Contents page listing many of the variables of the model. The first row, **Macros**, refers to the rows which have no subscripts (i.e., just one element). The other rows correspond to individual vector and matrix variables. Slowly move the mouse pointer (without clicking) over the various buttons and controls to get a hint about their purpose.



Double-click on the **macros** row to see the results for these variables. Select 3 decimal places.

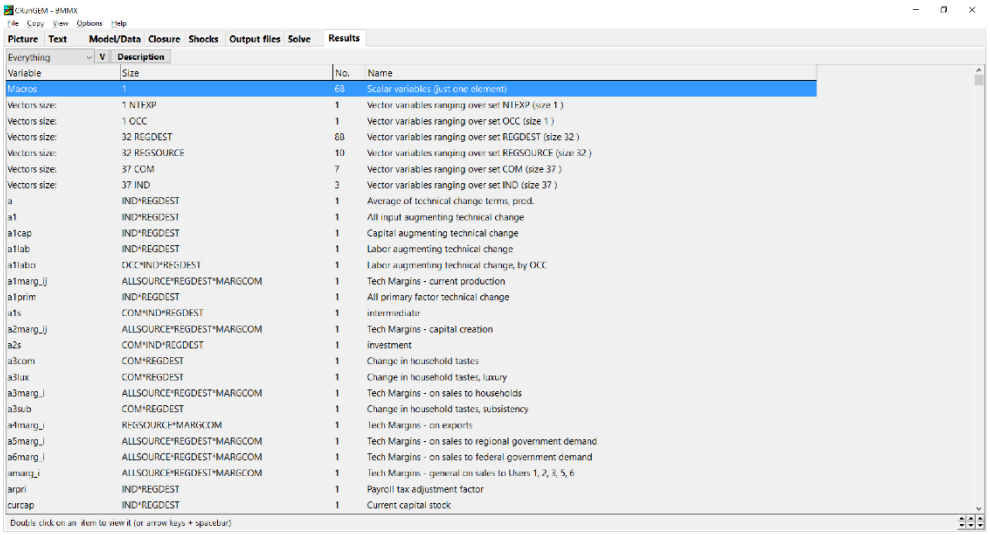


Exogenous variables are shown in red, including the shocked variable, **natphi**. Notice that all the quantity variables are unchanged (zero), while variables measured in currency units such as prices and values have all increased by 10%. In other words, the single exogenous price (called

numéraire) serves to determine the absolute level of prices but does not affect relative prices or, therefore, the behaviour of any agents.

Click the **Contents** button to return to the contents list.

To see the effects of another useful way of listing the variables in the **Contents** page, click on the **V** between the two drop-down list boxes near the top of the screen. You should see something like:



To see the results for all variables with a single argument ranging over the set **IND**, double-click on the seventh of the rows above (Vectors size: 37 IND). This time you will see the percent-change results for the 3 such variables (**natlabind**, **naty** and **natz**). When you have finished looking at these results, double-click on any number to return to the Contents list. Return to the other view of the Contents list by clicking again on the **V** button.

Q26. Which variable shows percentage changes in industry output (activity level)?

7.1. Looking at the updated data

As well as producing percent change simulation results, the simulation above produced an updated version of the MDATA file for the model (and also for PDATA). This updated database reflects the state of the economy as it would be after the shock (10 per cent increase in the *numéraire*). You can see this updated data by selecting

View | Updated Data | Updated MDATA

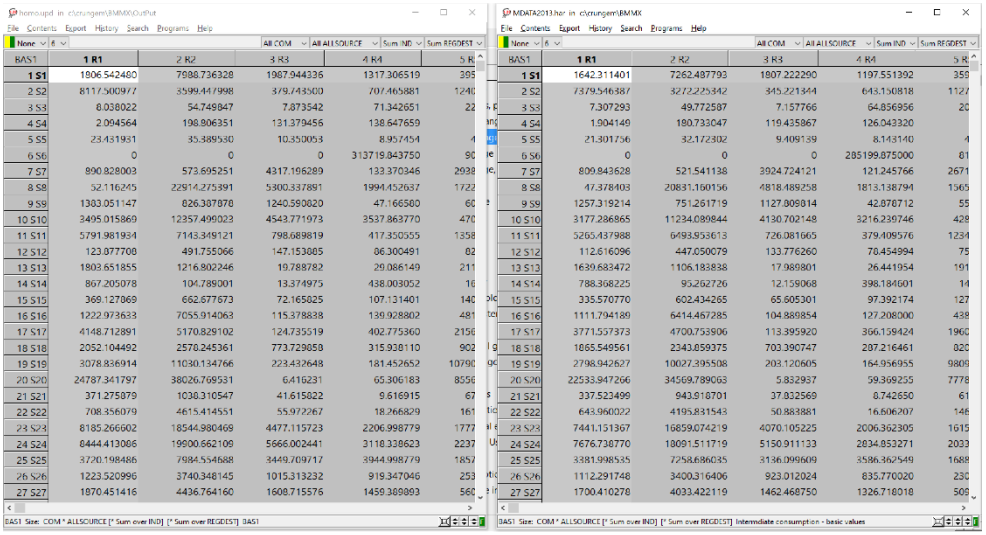
from the RunGEM menu. As usual, RunGEM opens ViewHAR to show you this data set. Double-click on the Contents row "BAS1". You should see the values of intermediate consumption of inputs from different sources, summed over all sectors and destination regions. Now click **(carefully**) in the **left** side of the button near the bottom right-hand corner of the ViewHAR window, to make this occupy just the **left** half of the screen.

Now, for the original (pre-simulation) version of this data, go back to RunGEM and select

View | Input Data | Original MDATA.

Again double-click to select the **USE** data and this time click carefully on the **right** side of the button to make this ViewHAR occupy the right-hand half of your screen.

Then (via the **Taskbar** or **Alt+Tab**), bring the other ViewHAR window (the one in the left-hand half of the screen) to the top.



BAS1	1 R1	2 R2	3 R3	4 R4	5 R
1 S1	1906.542480	7988.736328	1987.944336	1317.306519	395
2 S2	8117.500977	3599.447998	379.743500	707.465881	1240
3 S3	8.038022	54.749847	7.873542	71.342651	22
4 S4	2.094564	198.806351	131.379456	138.647659	
5 S5	23.431931	35.389530	10.350053	8.957454	4
6 S6	0	0	0	313719.843750	90
7 S7	890.828003	573.695251	4317.196289	133.370346	2938
8 S8	52.116245	22914.275391	5300.337891	1994.452637	1722
9 S9	1303.051147	826.307878	1240.590820	47.166560	60
10 S10	3495.015869	12357.499023	4543.771973	3537.863770	470
11 S11	5791.981934	7143.349121	798.689819	417.350555	1358
12 S12	123.077708	491.755066	147.153005	86.300491	82
13 S13	1803.651855	1216.802246	19.788782	29.086149	211
14 S14	867.205078	104.789001	13.374975	438.003052	16
15 S15	369.127069	662.677673	72.165025	107.131401	140
16 S16	1222.973633	7055.914063	115.378838	139.928802	481
17 S17	4148.712891	5170.829102	124.735519	402.775360	2156
18 S18	2052.104492	2578.245361	773.729858	315.938110	902
19 S19	3078.836914	11030.134766	223.432648	181.452652	10790
20 S20	24787.341797	38026.769531	6.416231	65.306183	8556
21 S21	371.275879	1036.310547	41.615822	9.616915	67
22 S22	708.356079	4615.414551	55.972267	18.266829	161
23 S23	8185.266602	18544.980469	4477.115723	2206.998779	1777
24 S24	8444.413086	19900.662109	5666.002441	3118.338623	2237
25 S25	3720.198486	7984.554688	3449.709717	3944.998779	1857
26 S26	1223.520996	3740.348145	1015.313232	919.347046	253
27 S27	1870.451416	4436.764160	1608.715576	1459.389893	560

BAS1	1 R1	2 R2	3 R3	4 R4	5 R
1 S1	1642.311401	7262.487793	1807.222290	1197.551392	359
2 S2	7379.546387	3272.225342	345.221344	643.150818	1127
3 S3	7.307293	49.772587	7.157766	64.856956	20
4 S4	1.904149	180.733047	119.435867	126.043320	
5 S5	21.301756	32.172302	9.409139	8.143140	4
6 S6	0	0	0	285199.875000	81
7 S7	809.843628	521.541138	3924.724121	121.245766	2671
8 S8	47.378403	20831.160156	4818.489258	1813.138794	1565
9 S9	1257.319214	751.261719	1127.909814	42.876712	55
10 S10	3177.286865	11234.089844	4130.702148	3216.239746	428
11 S11	5265.437988	6493.953613	726.081665	379.409576	1234
12 S12	112.616096	447.050079	133.776260	70.454994	75
13 S13	1639.683472	1106.183838	17.980801	26.441954	191
14 S14	788.368225	95.262726	12.159068	398.184601	14
15 S15	335.570770	602.434265	65.605301	97.392174	127
16 S16	1111.794189	6414.467285	104.889854	127.208000	438
17 S17	3771.557373	4700.753906	113.395920	366.159424	1960
18 S18	1865.549561	2343.059375	703.390747	287.216461	820
19 S19	2798.942627	10027.395508	203.120605	164.956955	9809
20 S20	22533.947266	34569.789063	5.832937	59.369255	7778
21 S21	337.523499	943.918701	37.832569	8.742650	61
22 S22	643.960022	4195.831543	50.883881	16.606207	146
23 S23	7441.151367	16859.074219	4070.105225	2006.362305	1615
24 S24	7676.736770	18091.511719	5150.911133	2834.853271	2033
25 S25	3381.998535	7258.686035	3136.099609	3586.362549	1689
26 S26	1112.291748	3400.316406	923.012024	835.770020	230
27 S27	1700.410278	4033.422119	1462.468750	1326.718018	509

When you have got both the original and the updated data side-by-side on your screen, take a moment to pat yourself on the back. You are truly a Windows wizard! Now look at a particular cell, say that corresponding to the value of intermediate usage of agriculture product from Aguascalientes (R1) (the top-left cell). Think what has happened to prices and to quantities in this simulation, and hence deduce what must have happened to values. Check that the pre- and post-simulation BAS1 values are consistent with this.[6] You might like to repeat this for some other cells in this or other headers. Close the two ViewHAR windows when you are finished.

Remember that the flows in the updated data are measured in terms of post-simulation prices. By comparing original and updated data, we can make deductions about values, but not about quantities.

[6] You should be able to confirm that the post-simulation value is exactly 10% greater than the original value. Right-click on the original value. A small window should appear: click first the **Copy** button, then the **Close** button. This puts the number in the Windows clipboard. Now launch the Windows calculator, and then **Edit...Paste** to enter in the number from ViewHAR. Multiply by 1.1 (***1.1=**) and you should see the same number as in the updated data. You can also do this in Excel.

8. Simulating the short-run effects of a drought in Northern Mexico

Most years, one or more regions of Mexico suffer from low rainfall. As a continuing result of climate change, during 2020 an unusually severe drought in Sinaloa is expected to affect farmers all over the region. Agricultural outputs will fall sharply, with an expected loss of 10% (what if climate variability would also affect cattle raising output?). We simulate the effects of such a drought using the BMMX ICGE model. Questions are scattered through the instructions. Write down answers to the questions onto the instruction sheet.

The simulation in the next example is one in which the shock is a

10% decrease in technical efficiency

Now look again at the TABLO Input file for the BMMX ICGE model.

Search | Find for the variable name **a1**. The first occurrence is the variable definition:

```
(all,j,IND)(all,q,REGDEST)
a1(j,q) # All input augmenting technical change #;
```

The "(all,j,IND) (all,q,REGDEST)" means that **a1** is a vector variable with one value for each sector in each region. Click on **a1** and press the ***Gloss*** button (at top middle of the screen). You can see that a1prim appears in 4 equations: the three demand equations E_x1o, E_x1oct and E_x1prim, and later on the long E_a equation. Click on the red line number at left of equation E_x1o and you should see:

```
E_x1o # Demand for dom./for. composite inputs, User 1 #
(all,i,COM)(all,j,IND)(all,q,REGDEST)
x1o(i,j,q)=z(j,q)+a1(j,q)+a1s(i,j,q);
```

Click on the = sign in the equation above and press the **Gloss** button to see a definition of each symbol that is used.

The terms "(all,i,COM)(all,j,IND)(all,q,REGDEST)" mean that Equation E_x1o is actually a group or block of equations: there is one equation for each "commodity composite"[7] used by each industry in each region. So if there were 37 commodities, 37 industries and 32 regions in the database there would be 43,808 (=37*37*32) separate equations. Each of the variables **x1o**, **z**, **a1**, and **a1s** is a percentage change: if **z("S20","R8")** had value 5, that would mean that output of the machinery industry in Chihuahua would be 5% greater than in the initial equilibrium described by the input data files. The "a" variables are technological change variables, normally exogenous (values fixed outside the model). Suppose output were fixed

[7] An example of a "commodity composite" might be mining used by the manufaturing sectors. Mining is potentially a mixture of local and imported mining products, so we call it a "dom/imp composite".

(**z**=0), a shock of 10% to **a1("S20","R8")** would mean that for each commodity c, the values of **x1o(c,"S20","R8")** must also increase 10% to keep the equation balanced. If you looked at the other equations where **a1** appears, you would find that a shock of 10% to **a1("S20","R8")** would mean that 10% more of *all* inputs were needed to produce a given S20 output in Chihuahua [note: positive **a1** implies technical *regress*].

Press ESC or spacebar to close the Gloss window.

Exit from TABmate in the usual Windows way by ***File | Exit.*** (There are usually alternatives in terms of keystrokes instead of the mouse action. For example, you can use keystrokes ***Alt*** followed by ***F*** followed by ***X*** in order to exit.)

8.1. Implementing the shock

Start up RunGEM with the BMMX ICGE model. Go to the ***Closure*** page. As in the previous example, use the ***Load closure*** button to select the **short run** closure file (BMMX.cls). Notice that the variable **a1** (all input augmenting technical change) is exogenous.

In this simulation, we shock the variable **a1** to increase by 10% for the agricultural sector (S1) in Sinaloa (**R25**). **a1** is a measure of overall technical efficiency – the 10% means either that with inputs held constant output will be 10% less, or that 10% more inputs will be needed to produce the original output. This shock is used to simulate the main effect of the drought: agricultural productivity in Sinaloa is reduced.

Go to the ***Shocks*** page and delete any existing shocks by clicking **Clear Shocks List**. Then specify the shock as follows:

1 Use the combo box[8] at the top to choose which **variable to shock**: click on the arrow at the right. This will show you a list of variables. Click on **a1**. This variable has dimensions **INDxREGDEST**.
2 Select the elements to shock: from the **ALL IND** drop-down list box choose **S1**. And from the **ALL REGDEST** list box, select **R25** (Sinaloa).
3 In the edit box labelled **value of shock**, type 10, meaning a 10% decrease in primary factors technical efficiency in the agriculture sector in Sinaloa. Then click the ***Add to shock list*** button.

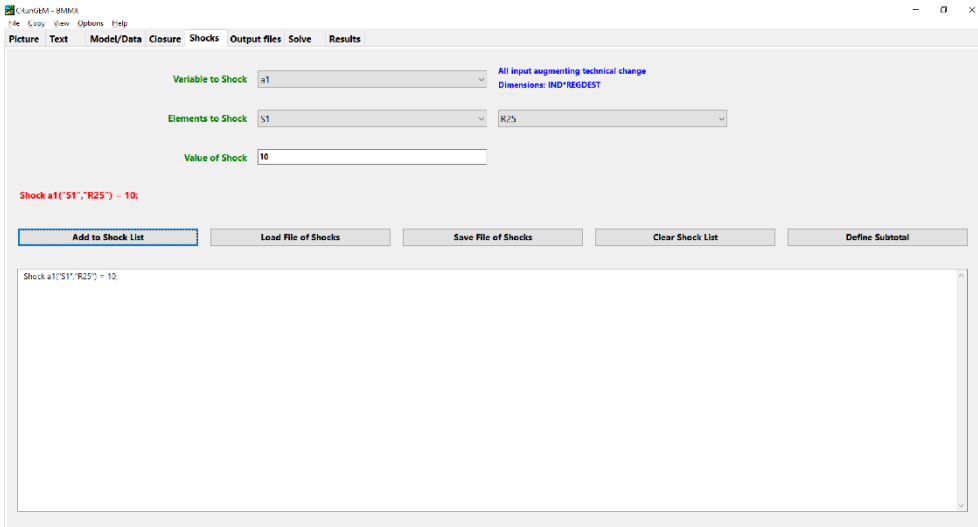
In this simulation, only one variable is shocked. If you wanted more shocks you would repeat steps 1, 2 and 3 for each variable that was to be shocked.

The shock list underneath should now contain:

Shock a1("S1","R25") = 10;

[8] A **drop-down list box** is also called a **combo box**.

You may edit it directly if necessary.



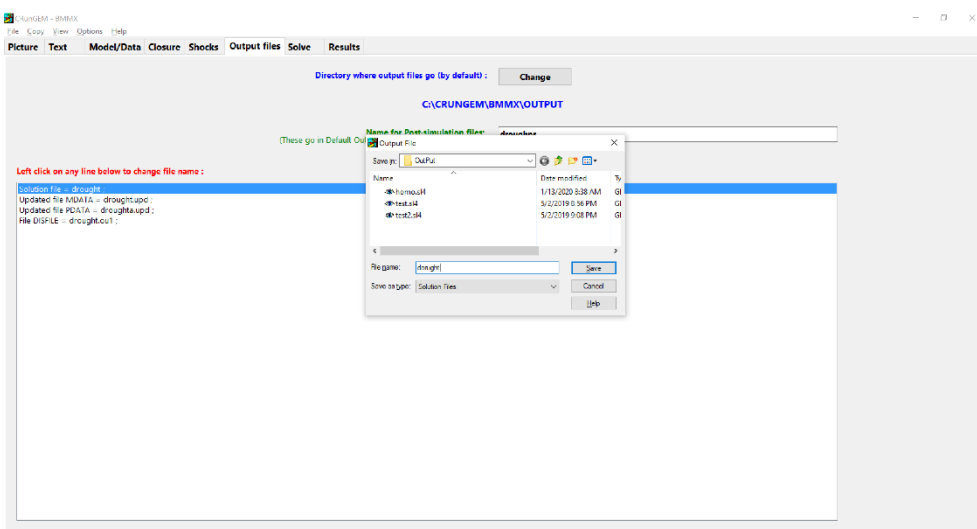
When you have finished with the shocks, go to the Output Files page.

8.2. Choosing a special name for output files

Later, we want you to compare the solution file from this simulation with another solution file. If you want to preserve solution files for later reference, you have to give a unique name for simulation output files. To do this, go to the Output Files page, and click on the line beginning

Solution file =

A file dialog will appear; type in a new name. This time, type **drought.SL4** [the suffix SL4 is compulsory]. Then click Save.



When you have set the name for output files, go to the Solve page.

8.3. Choosing the solution method and running the simulation

From the Solve page:

1 First, select the solution method to use. To do this, you would need to click on the ***Change*** button to the right of the **Solution method** label. [This button is the top-most button on the page.] In the ***Method*** part select **Euler (1-2-4).** [We will discuss the alternative methods later.]

2 Next notice the ***Verbal description*** label and the edit box to its right. It is good practice to enter a few words summarizing the simulation you are about to carry out. So first select the existing entry with your mouse and then replace it by

   10% decrease in productivity in the agricultural sector in Sinaloa

3 Now click the Solve button to start the solution process.

RunGEM runs the TABLO-generated program BMMX.EXE to solve the BMMX ICGE model.

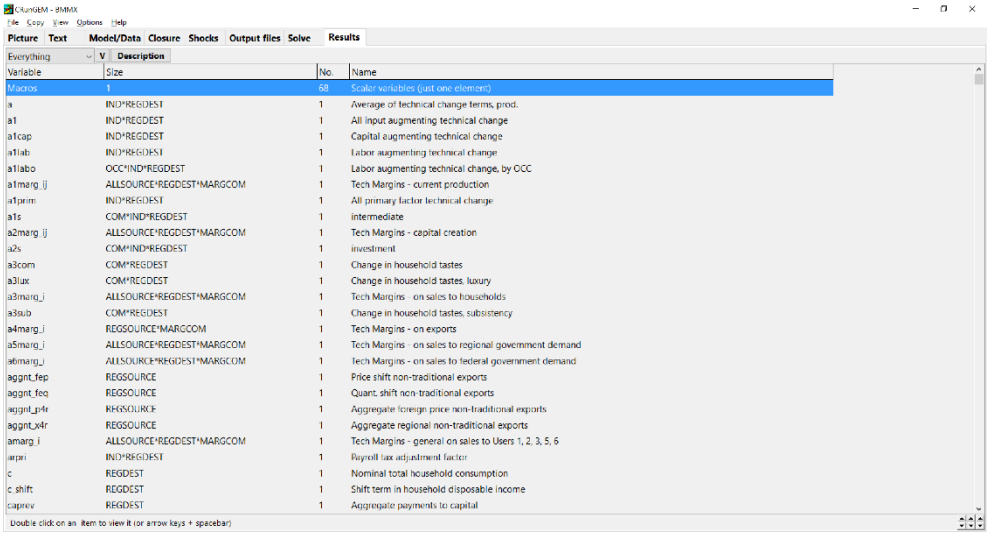
Once it has solved, RunGEM displays an accuracy summary chart showing how many variables are accurate in the levels to 1, 2, 3, 4, 5, or 6 figures. A little face summarizes overall accuracy – hopefully, it is smiling. Accuracy of the updated data is summarized in the same way. Click **Help** to learn more, then **OK** to proceed. Another message now tells how long the solution took.

8.4. Looking at the results

When the solution has been obtained, RunGEM will present you with a box telling you how long it took to obtain the solution. Close this and go directly to the ***Results*** page.

This page allows you to inspect the variable values computed during the **last** successful solution process. Initially, a **Contents** window is displayed, listing the model variables. You can double-click on the row containing the variable you are interested in to see its results in this simulation. As you saw previously, you can also use the button marked **"V"** to arrange the contents list in two ways:

- variables listed individually;
- variables ranging over the same set grouped together.



You can also look at the results using ViewSOL. First click on the button

View | Solution via ViewSOL

The Contents screen shows the names of the variables. To see the values of a variable, double-click on its name. To return to the Contents screen, double-click on any number (or select Contents in the ViewSOL menu).

Start by double clicking on the first Contents row: **Macros** (Macros are scalar variables or variables with just one component). You should see a list of macro variables and the value of their changes. You can click on the variable names – a description will appear at the bottom of ViewSOL. Use the decimal places combo box at top right to set the number of decimal places to 3.

Most of the variables are percentage changes, but some are ordinary changes, measured in million-MXN. Values for exogenous variables are shown in red. Scroll down the list to find price indices, nominal values, and quantity indices.

Q27. Write down below what happened to:

natexpvol: export volumes
natgdpreal: real GDP from expenditure side
natemploy: national employment
natimpvol: import volume
natxi4: exports price index
natxi3: consumer price index
natpwage: aggregate nominal wages to workers

Double-click on any number to return to the Contents screen. Then scroll down until you find the variable **natz** (activity level). Double-click to view the numbers.

Q28. Which manufacturing sector (S11-S22) was most affected?

Return to Contents and view regional results for:

x4r: export volume
xi3: regional consumer price index

Q29. Compare the results for **c** (nominal total household consumption) and **yd_r** (household disposable income). What do they suggest? Can you find in the BMMX.TAB file the relevant equation?

Q30. Look at the results for **yr** (real GRP), **l** (aggregate employment) and **z** (activity level by sector). Which region is the main loser? Which regions were relatively less affected in real GDP terms? Can you think why?

8.5. Changing the solution method

In this example, you will tell RunGEM to solve the model using Johansen's method. With Johansen's method, only approximate solutions are obtained to the nonlinear levels equations of the model. GEMPACK also provides multi-step solution procedures referred to as **Euler's** and **Gragg's solution methods.** Coupled with **extrapolation** (a standard numerical method used in various branches of science and engineering), these are able to provide accurate solutions of the levels equations of the model, as was the case in the example above.

To change the solution method in RunGEM go to ***Solve*** and click on the ***Change*** button to the right of the **Solution method** label. [This button is the top-most button on the page.] In the ***Method*** part select **Johansen**. Then click ***Ok***, and go to the Output Files page.

8.6. Choosing a special name for output files

Later we want you to compare results from this simulation with those from the previous simulation that used the **Euler** solution method. This means that you must specify a unique name for the output files that the next simulation will produce. To do this, go to the Output Files page, and click on the line beginning **solution file =**. A file dialog will appear; type in the name droughtj.SL4. Then click Save.[9]

[9] If you do not give a new name for the SL4 file, RunGEM uses the same name as before, and so overwrites the previous solution file. This might be annoying! You can use Explorer to delete files in the Output directory (maybe to save disk space).

8.7. Running the Johansen simulation

Now go to the ***Solve*** page and click the ***Solve*** button. A "Please Wait" window will appear while the model is solved. Then RunGEM will show you a box telling you how long the solution took. Just press OK.

8.8. Using ViewSOL to compare two sets of results

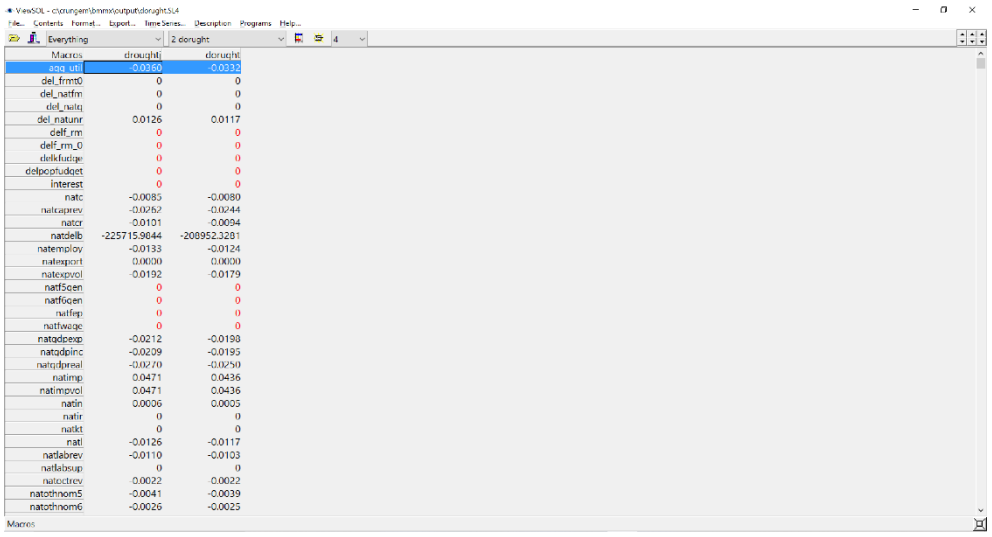
The RunGEM Results page lets you see only the most recently-computed solution. Sometimes you want to view 2 solutions at once. You can do that using the ViewSOL program which comes with RunGEM.

We assume that RunGEM is open and you have just successfully completed the steps described in previous sections.

Now select the menu item ***View | Solution via ViewSOL***. The ViewSOL program will open the most recent solution[10] and show a Contents page. In general, ViewSOL works very like the **Results** page of RunGEM. For example, you can double-click on a variable to see its values.

Now, use the ViewSOL menu command ***File | Open*** to open the solution file **drought.SL4**. This ought to contain results from the previous, Euler 1-2-4, simulation.

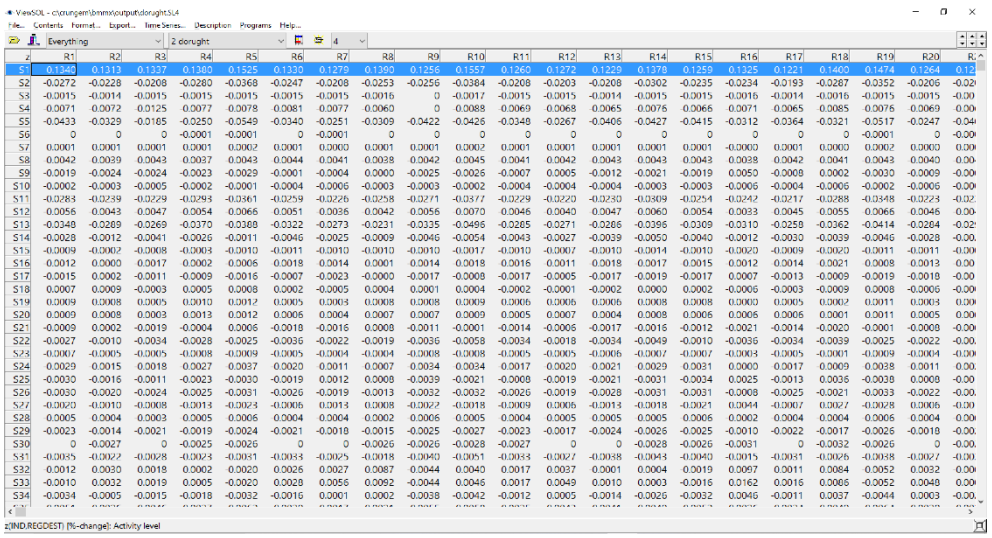
ViewSOL Contents will again appear. ViewSOL offers a choice of formats for this Contents list. Select ***Format.*** from ViewSOL's main menu and there click on ***Arrange vectors by name*** (in the panel headed Vector options); also click the button ***Order Variables alphabetically***; then click ***Ok*** which will put you back to the Contents list. Now double-click on the **Macros** row and you should be able see both solutions together.



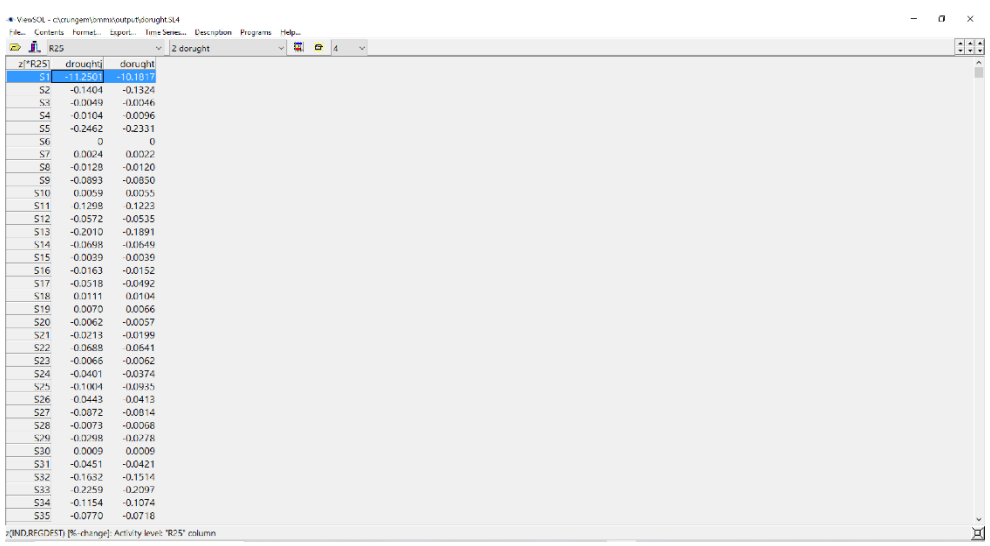
[10] ViewSOL displays a short quotation (either inspiring or corny) while it is loading the solution file.

Q31. Do you think that the differences between Johansen and Euler solutions are significant?

Go back to the ViewSOL contents list and double click on the row for **z**, a matrix variable (this will be near the end of the contents list). This time you will only see results for one simulation. But you can use the **solution list box** (see picture) to switch between the two solutions. The Description menu item gives details of the currently selected solution.



Now use the Filtering list box to select only the **R25** (Sinaloa) component of matrices. This takes you back to the contents screen. Double-click on the **z[*,R25]** row (probably the last row). You should see results for the Euler and Johansen simulations side-by-side:



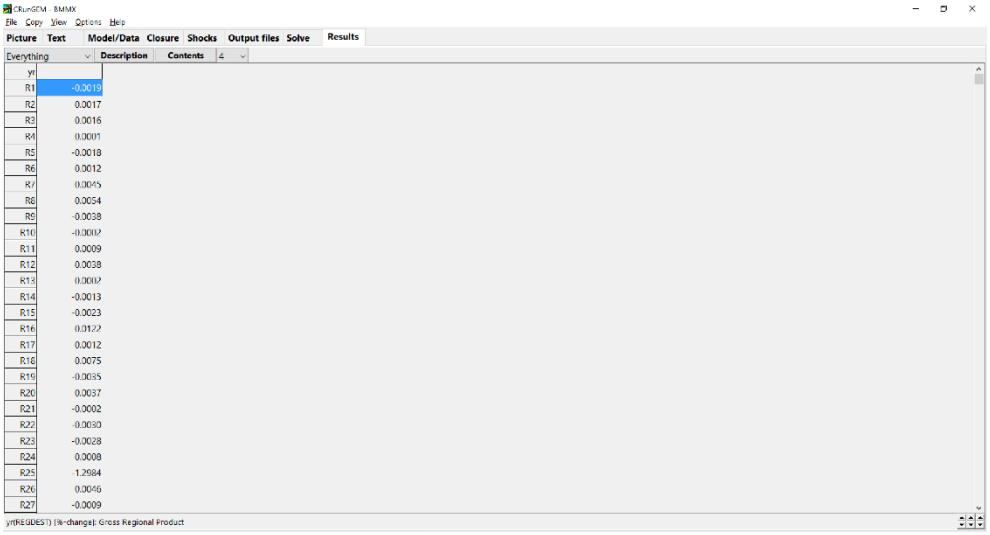
When you have finished looking at the results, exit from ViewSOL.

8.9. Copying results into a spreadsheet

RunGEM makes it easy for you to copy simulation results (or data) into other windows programs such as spreadsheets or word processors. You will find this invaluable when you are preparing reports.

As an example, below we set out the simple steps needed to copy the **yr** results from the previous simulation into Excel (or another spreadsheet).

Go to the Contents page of the ***Results*** and then select the **yr** results. You should see something like:



Now click on ***Copy*** from RunGEM's main menu. A message **Data copied to Clipboard** will appear for a moment.

Now start Excel (or your favourite spreadsheet program) running. In a new sheet, click on the top left-hand cell and then select ***Edit | Paste*** from the main menu. You should see the above table appear in Excel. Note that the number of decimal places selected in RunGEM affects the exact numbers copied.

[If you want to check whether there is a correlation between regional performance in terms of GRP and the share of agriculture in total value added (need to calculate that!), as suggested in Q30, create a scatter plot using the appropriate variables – exclude the observation for Sinaloa.]

Close Excel.

In ViewHAR and ViewSOL, the **Export** command lets you copy data to Excel in just the same way.

When you have finished looking at the results, exit from RunGEM and other related programs.

9. An experiment with multiple shocks: TFP-enhancing policy in KIBS in Mexico

General equilibrium modellers need to explain their results. A general equilibrium model has various main mechanisms that produce the results. The modeller is required to identify and quantify those that are important for a particular simulation. To analyse the results in this way, the modeller must bring together details of several different information sources: the equations of the model, the base data, consequences of that data such as totals and shares, and the simulation results (percentage changes or ordinary changes). For this exercise, you can find the story behind the simulation (told in the Colombian context) in the companion paper "The Interplay of Services Productivity and Competitiveness of Colombian Exports", by Haddad, Araujo, Oliveira and Pacheco (*forthcoming*).

This section presents another example with the BMMX ICGE model: a multi-sectoral TFP-enhancing simulation. The example is presented as exercises for the reader to follow.

9.1. Preparing the shock file

The simulation shows the long-run effects of a uniform 1% TFP gain in Knowledge-Intensive-Business-Services (KIBS) sectors across all Mexican regions.

There is substantial value-added of services incorporated in goods exports, from intermediate services and from services bundled with goods, which is not captured in the original four modes of supply defined in WTO's General Agreement on Trade in Services (GATS). In the context of increasing international fragmentation of production chains and the emergence of Global Value Chains (GVC), gross export statistics may be inaccurate to measure a country's participation in international trade. Looking directly at gross exports of goods and services may affect how a country chooses priority partners in trade agreement negotiations, and may also bias the impact analysis of international demand shocks, for instance. A more appropriate measurement should consider the value-added by each country in the production of goods and services that are consumed worldwide. Moreover, if one is interested in sectoral-specific trade policies, it would be important to map the contribution of value-added to trade flows by sector or group of sectors (e.g. services) in different countries. Thus, a fifth mode of supply, mode 5, was defined to account for services that are incorporated into goods, which are then traded across international borders.

In the quest for increasing and sustaining its competitiveness in GVC, Mexico still requires policies, capabilities and infrastructure to promote intermediate services. On one hand, the continuing development and upgrade of its connectivity infrastructure, to enhance productivity of distribution, transportation, and communication services, will help to promote linking tasks *within* and *across* countries. Locational aspects of these groups of sectors, especially transportation services, are associated with relatively less concentrated spatial patterns, as production and consumption are more strongly locationally interdependent. On the other hand, KIBS tend to be highly concentrated at a country level. However, this does not exclude some movements towards dispersion observed in some business services, as long as working skills limitations are surpassed, which may give room for coordinated regional and trade policies to enhance participation in value addition in Local Value Chains (LVC) of peripheral, natural

resource-rich, exporting regions. To explore the effects of such policies, the BMMX ICGE model is used to simulate the impacts of a TFP-enhancing shock in Mexican KIBS sectors.

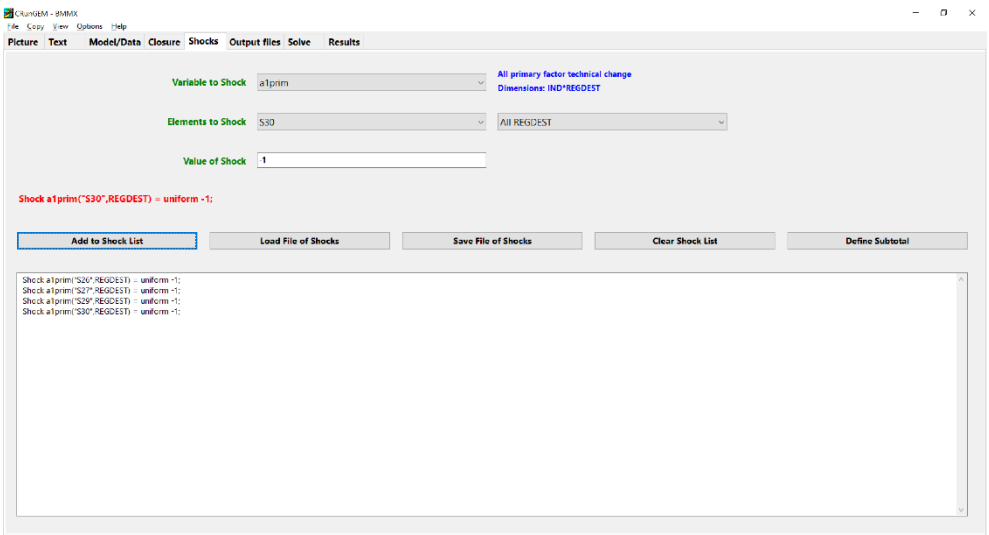
Q32. Find in the file BMMX.TAB the occurrence of the variable **a1prim**. In which equations does it appear? What role does it play?

The details of the shock sizes are contained in the file TFP_KIBS.SHF.

9.2. Implementing the shocks and running the simulation

Start up RunGEM with the BMMX model. Go to the ***Closure*** page. As in the previous example, use the ***Load closure*** button to select the **long run** closure file (LONGRUN.cls). Notice that the variable **a1prim** is exogenous:

Then go to the ***Shocks*** page and delete any existing shocks by clicking **Clear Shocks List**. Then specify the shocks as follows: click on **Load File of Shocks** and select the previously prepared shock file **TFP_KIBS.SHF**. In our simulations, we will consider the following sectors as KIBS: information services (S26), financial services (S27), professional, scientific and technical services (S29), and business services (S30).



The shock list underneath should now contain:

Shock a1prim("S26",REGDEST) = uniform -1;
Shock a1prim("S27",REGDEST) = uniform -1;
Shock a1prim("S29",REGDEST) = uniform -1;
Shock a1prim("S30",REGDEST) = uniform -1;

When you have finished with the shocks, go to the Output Files page. There, click on the line there that begins **Solution file =**. In the file dialog; type in the name **tfplr.SL4**. Then click Save.

Now go to the ***Solve*** page:

- First, select the solution method to use. To do this, click on the ***Change*** button to the right of the **Solution method** label. In the ***Method*** part select **Euler** and then make sure that you have **3 solutions** and **1, 2, 4 steps**. [Select these if they do not become selected after you click on "Euler"]. Check also the radio button **Automatic Accuracy**. Then click **OK**.
- Next notice the ***Verbal description*** label and the edit box to its right. It is good practice to enter a few words summarizing the simulation you are about to carry out. So first select the existing entry with your mouse and then replace it by

  1% increase of TFP in KIBS

- Now click the ***Solve*** button to start the solution process.

RunGEM runs the TABLO-generated program BMMX.EXE to solve the BMMX ICGE model.

9.3. Looking at the results

When the solution has been obtained, RunGEM will present you with an accuracy summary and a box telling you how long it took to obtain the solution.

Once it has solved, RunGEM displays an accuracy summary chart showing how many variables are accurate in the levels to 1, 2, 3, 4, 5, or 6 figures. A little face summarizes overall accuracy – hopefully, it is smiling. Accuracy of the updated data is summarized in the same way. Click **Help** to learn more, then **OK** to proceed.

Another message now tells how long the solution took. Click **OK** then select ***View | XAC file***. TABmate will show you the Extrapolation Accuracy File where you can see the effect of the solution method and the extrapolation. To be specific, search for **natgdpreal** (real GDP from expenditure side). This row of the XAC file is

```
5.462481E-02    5.445847E-02    5.437561E-02    5.429295E-02 CX  4 L6
```

Here the results are respectively the 1-step (5.462481E-02), the 2-step (5.445847E-02), the 4-step (5.437561E-02) and the extrapolated result (5.429295E-02), with one sub-interval.[11] The notation CX 4 means that you can be **C**onfident in the e**X**trapolated result (this is the CX) and you can be confident that at least 4 of the figures (that is, at least the 0.054 part) in the extrapolated result are accurate. The L6 means that at least 6 figures in the corresponding levels result (as distinct from the percent-change result) are accurate.

Close this and go directly to the ***Results*** page.

Look first at the results for **a1prim** (tech margins on exports). Check that the relevant components of the variable were indeed shocked.

[11] To obtain this results, you should define only one sub-interval when choosing the solution method.

Then look at the macro results.
Q33. What was the effect on the variables listed below?

Real GDP (*natgdpreal*)
Real Household Consumption (*natcr*)
Activity Level (*natz_tot*)
Employment: Persons (*natemploy*)
Unemployment Rate (% point change) (*del_natunr*)
Nominal Wage Paid by Producers (*natpwage_p*)
GDP Price Index (*natxigdp*)
Consumer Price Index (*natxi3*)
Export Volume (*natexpvol*)
Import Volume (*natimpvol*)

Look over the real GRP results (**yr**).

Q34. Which regions are the main losers and gainers? Can you say anything about the long-run effects of KIBS-TFP-enhancing shocks on regional inequality?

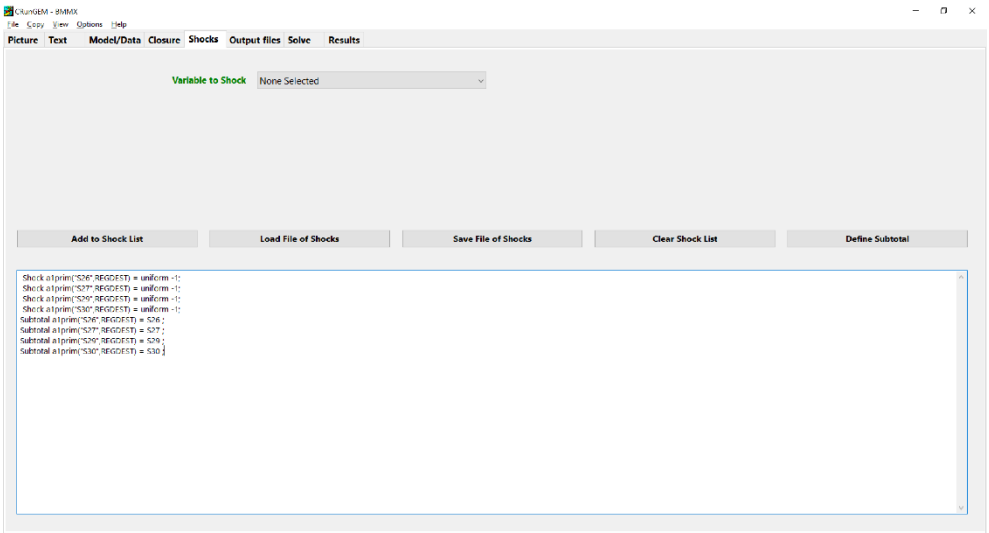
9.4. Using Subtotals to divide up the effects of the shocks

If your simulation involves several different shocks, GEMPACK offers you a very powerful facility known as "subtotals". This allows you to divide the total change in any endogenous variable between the various shocks.

Try it out using the productivity shocks described above [if necessary, use **Load file of shocks** on the Shocks page to reload the **TFP_KIBS.SHF** shock file that you saved, and rerun the simulation]. Divide the total change in four different subsets of shocks that relate to each of the sectors: (i) information services (S26); (ii) financial services (S27); (iii) professional, scientific and technical services (S29); and (iv) business services (S30). Go to the ***Shocks*** page and carefully type the following lines underneath the list of shocks:

Subtotal a1prim("S26",REGDEST) = S26 ;
Subtotal a1prim("S27",REGDEST) = S27 ;
Subtotal a1prim("S29",REGDEST) = S29 ;
Subtotal a1prim("S30",REGDEST) = S30 ;

Then go to the ***Solve*** page and click the ***Solve*** button.



When the solution has been calculated, examine the macro results. You should see 5 columns of numbers. The first column shows the same changes that were calculated before. The next 4 columns show how much of the total change in each variable may be attributed to the exogenous changes in TFP in each of the four KIBS sectors. Click on the ***Description*** button above the results to verify this.

Q35. Which kind of "improved TFP" produces the biggest impact on national GDP?

Q36. Look at the real GRP results (**yr**). In relative terms, which region benefits most from the increase in TFP of KIBS sectors? And which region benefits least? Can foreign exposure explain part of the results?

Go back to the Shocks page and click the Define Subtotal button. This launches a window that can help you compose subtotal statements like the three that you added before. Use the Help button to find out how to use this window, and to find out more about the theory behind subtotals.

Q37. Can you tell if the improved TFP of KIBS located in Ciudad de Mexico (R9) was more beneficial to other regions than the improved TFP of KIBS in Nuevo Leon (R19)? To answer this question, you will need to edit the command to compose subtotals.

Q38. Why is the improvement of the TFP of KIBS in other regions bad for Ciudad de Mexico (R9)? Check that they all present negative impacts in R9's real GRP (**yr**).

10. Customized RunGEM and the complete GEMPACK system

The ***Customized RunGEM with BMMX ICGE*** package that you have been using is especially arranged and simplified to suit newcomers to CGE modelling using GEMPACK, in general, and the BMMX ICGE model, specifically. You might wonder how similar using the full GEMPACK system would be.

One difference is that RunGEM looks after *file management*: it controls the names and locations of the dozen or more files used for each GEMPACK simulation. An advanced GEMPACK user has to assume more of this responsibility.

Another difference is that users of the full GEMPACK system often wish to alter the data and specifications of the model. So they have to:

- use ViewHAR to create and modify the HAR files that contain data;
- edit the TAB file, then run the TABLO program to turn the TAB file into a model-solution program.

This document does not describe the many features of ViewHAR and TABmate that are aimed at these tasks. Also, you must buy a GEMPACK licence to run TABLO, to run larger models, or to modify larger data files. Finally, the full GEMPACK system contains many other programs, not described here.

Nevertheless, if you have worked through this document (and mastered the companion documents that describe the theory of the BMMX ICGE model) you are well on the way to becoming a competent CGE modeller. You should understand the basic theory which underlies BMMX ICGE – the same theory is used in every other CGE model. You can read and understand a TAB file – so now you have access to the large number of CGE models that use this notation. The tools that you have been introduced to, such as ViewHAR and TABmate, are the same tools used by other CGE model builders. Even the syntax used in RunGEM's Closure and Shocks pages is identical to the corresponding parts of the Command files (CMF files) required in GEMPACK for carrying out simulations.

The GEMPACK web page, at:

https://www.copsmodels.com/gempack.htm

gives access to a great deal of GEMPACK related information, such as details of the GEMPACK product range and licensing arrangements, but also including much free stuff. For example, you could download the **Demonstration version of GEMPACK** which gives access to the full range of GEMPACK capabilities but is limited to very small models.

Appendix 1: Installing Customized RunGEM

The Customized RunGEM for the BMMX ICGE model is delivered as a single large EXE file, called CRUNGEMX.EXE, and a folder with the BMMX ICGE model files. You might have downloaded this EXE file from the Internet (https://www.copsmodels.com/crungem.htm) and saved it in your TEMP folder. CRUNGEMX.EXE is a self-extracting archive which, when you run it, launches a conventional install procedure. Alternatively, you can download CRunGEM from the course area in www.usp.br/nereus.

The install procedure tells you how much free hard disk space you will need. You might have to clean up your hard drive before proceeding. It is best to install into a folder named C:\CRUNGEM. Avoid directory names that contain spaces, commas or Arabic characters or are more than 8 letters long.

The package will typically include other models as well. To have the BMMX ICGE model running properly, you should copy the BMMX folder into the folder C:\CRUNGEM. If you want to launch the BMMX ICGE model directly from double-clicking on the Customized RunGEM icon that will appear on your desktop after installation, you should delete all other **folders** in C:\CRUNGEM, except C:\CRUNGEM\BMMX and C:\CRUNGEM\work.

The final step to complete the installation is to copy the \GP folder (also available at the course area in www.usp.br/nereus) directly to the C: drive.

Customized RunGEM assumes that the user has his own copy of the program on his own hard drive. The program cannot be installed on a network drive and used by several people at once.

Appendix 2: List of regions and sectors of the BMMX ICGE model

R1	Aguascalientes
R2	Baja California
R3	Baja California Sur
R4	Campeche
R5	Coahuila de Zaragoza
R6	Colima
R7	Chiapas
R8	Chihuahua
R9	Ciudad de México
R10	Durango
R11	Guanajuato
R12	Guerrero
R13	Hidalgo
R14	Jalisco
R15	Mexico
R16	Michoacan de Ocampo
R17	Morelos
R18	Nayarit
R19	Nuevo Leon
R20	Oaxaca
R21	Puebla
R22	Queretaro
R23	Quintana Roo
R24	San Luis Potosi
R25	Sinaloa
R26	Sonora
R27	Tabasco
R28	Tamaulipas
R29	Tlaxcala
R30	Veracruz de Ignacio de la Llave
R31	Yucatan
R32	Zacatecas

S1	Agricultura
S2	Cría y explotación de animales
S3	Aprovechamiento forestal
S4	Pesca, caza y captura
S5	Servicios relacionados con las actividades agropecuarias y forestales
S6	Minería petrolera
S7	Minería no petrolera
S8	Generación, transmisión y distribución de energía eléctrica
S9	Suministro de agua y de gas por ductos al consumidor final
S10	Construcción
S11	Industria alimentaria
S12	Industria de las bebidas y del tabaco
S13	Fabricación de insumos textiles y acabado de textiles; Fabricación de productos textiles, excepto prendas de vestir
S14	Fabricación de prendas de vestir; Curtido y acabado de cuero y piel, y fabricación de productos de cuero, piel y materiales sucedáneos
S15	Industria de la madera
S16	Industria del papel; Impresión e industrias conexas
S17	Fabricación de productos derivados del petróleo y del carbón; Industria química; Industria del plástico y del hule
S18	Fabricación de productos a base de minerales no metálicos
S19	Industrias metálicas básicas; Fabricación de productos metálicos
S20	Fabricación de maquinaria y equipo; Fabricación de equipo de computación, comunicación, medición y de otros equipos, componentes y accesorios electrónicos; Fabricación de accesorios, aparatos eléctricos y equipo de generación de energía eléctrica; Fabricación de equipo de transporte
S21	Fabricación de muebles, colchones y persianas
S22	Otras industrias manufactureras
S23	Comercio al por mayor
S24	Comercio al por menor
S25	Transportes, correos y almacenamiento
S26	Información en medios masivos
S27	Servicios financieros y de seguros
S28	Servicios inmobiliarios y de alquiler de bienes muebles e intangibles
S29	Servicios profesionales, científicos y técnicos
S30	Corporativos
S31	Servicios de apoyo a los negocios y manejo de residuos y desechos, y servicios de remediación
S32	Servicios educativos
S33	Servicios de salud y de asistencia social
S34	Servicios de esparcimiento culturales y deportivos, y otros servicios recreativos
S35	Servicios de alojamiento temporal y de preparación de alimentos y bebidas
S36	Otros servicios excepto actividades gubernamentales
S37	Actividades legislativas, gubernamentales, de impartición de justicia y de organismos internacionales y extraterritoriales

Appendix 3: Answers to questions in the text

Q1
Q2
Q3
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