Price changes and the input-output model

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Abstract

This paper aims to review the price transmission channels based on the input output matrix (I/0). Mainly, we propose a simple linear method to assess the impact of price change of the homogenous good of a given sector on the rest of prices. In short term, we assume that the introduced price change is exogenous and cannot be adjusted within the country markets. In this case, we show that the producer price must be adjusted to cover at least the change in the cost of inputs. We review also the Liontief approach, and where prices in long term are assumed to be adjusted to insure the same marginal profit across sectors. The paper discusses also on how to estimate the price changes of the usual main post consumption goods based on price changes within the SAM structure. Finally, we introduce a user friendly Stata model to perform the computation of price changes.

Key words : Price change; SAM matrix.
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1 Introduction

During the last years, there has been a growing interest to study the impact of the variation in prices of the energetic products on household wellbeing and the economic performance. The increase in price of energetic products may be driven through the world price increase within the free market of the country, or indirectly by reducing the subsidy to face the budget pressures. In this paper, our aim is to propose an easy framework to analyse the impact of the variation in prices intermediate goods on household wellbeing. Mainly, the increase in price of a given intermediate good will have an effect on prices of final goods. This will allow to the producers to cover the increase in production cost, and in long term, to maintain the same marginal profit. When we focus on the impact of change in price of intermediate goods on household well-being, we have to start by assessing the impact of this increase on prices of the final goods. Indeed, consumer theory tells us that the household will-being -indirect utility- depends on the level of income and that of prices of the final consumed goods.

Of course, one can assume that capital rent and labor wage may vary with the change in prices of intermediate goods. However, these revenues can continue to be practically constant with the assumption of higher rigidity of adjustments of wages and capital returns, like in the case where the government controls the wage structure. With this rigidity assumption how can we capture the bulk part of change in prices of final goods after a given increase in price of intermediate goods?

Generally, we can have a consensus that the cost of production of a given good depends on the cost of inputs. However, the impact of an increase in price of given input on that of the final good will depend on the intensity of use of that input. The modeling the transmission channels of price changes is not an easy task. As we can discover in what follow, this will depend on the adopted approach, as well as on the adopted assumptions. Mainly, the basic assumption in this paper is that the producer seeks to cover the increase in cost in the shorter term, but in the long term the adjustments must insure, with the assumption of competitive markets, the equality of the marginal benefits across sectors.

The needed basic information to assess the change in price of final goods is:

- the intensity of use of intermediate goods;
- the exogenous change in prices of the intermediate goods.

The information about intensity of use of the different inputs can be found Input/Output matrix. Mainly the input output matrix is a reduced or a synthesized form of representation of the economics of country through the interaction between their different main branches. This was render possible after the development of national accounting. The I/O matrix enables to show the interdependencies between different branches of a national economy or different regional economies. More important, for our study, it enables to show the importance of the different intermediate products for each branch-product. The rest of the paper is organized as follow. In section 2, we introduce and discuss the theoretical framework to assess the change in price of the final goods, which are induced by the change in prices of intermediate goods. In section 3, we apply the proposed methods using the Moroccan and Tunisian data. We conclude in section 4.

2 The I/O matrix and price changes, the theoretical framework

2.1 The short term impact of price change of inputs

Assume the presence n economic branches that produce homogenous goods. Further, we denote the cost share of input j for the production of i by $a_{i,j}$. Let the matrix A defined as follows:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

The initial normalised price of final good$j$ is equal to:

$$p_j = 1 = p_1 a_{1j} + p_2 a_{2j} + \ldots + p_n a_{nj} + \quad v_j \tag{2}$$

where v_j is simply the share of value added (labor and capital rents). Let l denotes the economic sector that is concerned by the exogenous chock or price change. To control for the exogenous nature of this price chance, we start by deriving the matrix B, which is similar to A except the following elements:

- $b_{l,l} = 1$
- $b_{i,i} = 0 \, if \, l \neq i$
- $b_{l,j} = 0 \, if \, l \neq j$.

Thus, the matrix B will take the following form:

$$B = \begin{bmatrix} 0, \, a_{1,2\,;} & \cdots & a_{1,n} \\ b_{i,1} = 0 & b_{l,l} = 1 & b_{i,n} = 0 \\ a_{n,1\,;} a_{n,2\,;} & \cdots & 0 \end{bmatrix} \tag{3}$$

The matrix B is helpful to model the assumption of exogenous change in price of the intermediate good l, and then to keep it constant. If we denote the vector of the proportional changes of prices by dP, the proposed model of price change in the shorter term is:

$$dP \;\; = BB_l \quad dp_i \tag{4}$$

Where B_l is the l_{th} column of matrix B. At this stage, we can discuss the relevance of the proposed rules to derive the matrix B:

- By setting $b_{i,i} = 0 \, if \, i \neq l$, we propose to control for the redundancy of the impact of price changes. In other words, we are not interested to the parsimonious or high orders of price effects.
- By setting $b_{l,l} = 1 \, and \, b_{l,j} = 0 \, if \, l \neq j$, we force the change in price of good l to be equal to the assumed exogenous increase: dp_l.

Note that the model assumes that consumer prices are simply and directly affected by the change in producer prices. Of course, the model can be updated to support other considerations. To illustrate how this model functions, we propose to discuss this with a simple hypothetical example. Let an economy with three sectors or three homogenous products. The matrices A and B of this hypothetical economy are defined as follows:

$$A = \begin{bmatrix} 0.2 & 0 & 0.5 \\ 0.2 & 0.3 & 0.2 \\ 0.3 & 0.4 & 0.1 \end{bmatrix} \text{ and } B = \begin{bmatrix} 0.0 & 0.0 & 0.5 \\ 0.0 & 1.0 & 0.0 \\ 0.3 & 0.4 & 0.0 \end{bmatrix} \tag{5}$$

Further, assume that the price of good 2 increases by 10%, i.e. $dp_2 = 0.1$. By applying the proposed model, we find that:

$$dP = \begin{bmatrix} 0.02 \\ 0.10 \\ 0.04 \end{bmatrix}$$

1. The first product do not use the second as intermediate, but it uses the third with an intensity of 50%. The third uses the second with an intensity of 40%. Thus, the approximated increase in price of the first good is dp_1 =0.1*0.4*0.5= 0.02

2. Since, the increase in price of product 2 is exogenous the change in price is equal to 10%: $dp_2 = 0.1$.

3. The third good uses the first as an intermediate product, but the first do not use the second. It uses also the second with and intensity of 40%. Thus, the increase in its price is equal to 0.4*0.1: $dp_3 = 0.04$.

Note that the transformation: matrix A to B designs the manner of modeling the transmission channel of prices.[1] With the proposed approach, the change in price of inputs is assumed to be exogenous (word price of fuel for instance). The increase in price of final goods will depend on the intensity use of the intermediate good. Of course, the proposed model can be refined to support other considerations. However, this model represents the basic framework to capture the bulk part of price changes of the final goods. Once this estimation is performed, one can move to the second step and assess the impact on household wellbeing. In what follows, we introduce briefly another popular model.

2.2 The long-term impact of price change of inputs

Mainly, we assume that the Liontief I/O model conditions are relevant to assess the changes in prices in the long term. Basically, this model assumes the presence of competitive markets and the full adjustment of prices in the long term. Among the other assumptions we find:

- *Armington assumption* : foreign goods are not a perfect substitute of the domestic goods;

[1]The basic assumptions about the rigidity in price adjustments are crucial in estimating the price changes. See also Wu, Li, and Zhang (2011) and Carvalho and Lee (2011).

- *Constant marginal profit*: The marginal profit of the sectors is not influenced by the change in cost. The producer/consumer prices must increase to absorb all of the impact of the intermediate price chocks.

Formally, the price equilibrium in initial state is defined as follows:

$$P_0 = (I - A)^{-1} V \tag{6}$$

Let the matrix T modeling the price chocks such that:

$$T = \begin{bmatrix} 1 + t_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 + t_n \end{bmatrix} \tag{7}$$

where t_i is the proportion of increase in price of the intermediate good i. Based on this, the new equilibrium which ensures the constancy of marginal profits is: [2]

$$P_1 = (I - A * T)^{-1} V \tag{8}$$

Note that the vector P is also called the producer equilibrium price structure. Also in this case, we may need to update the model by considering the information on trade and transportation margins.

2.3 Assessing the direct and indirect effect of price changes on household wellbeing

Some products, like fuel and theirs derivatives, can be consumed directly by households, or also, used as intermediate goods by the producer. By the *direct effect*, we refer to the impact of change in prices of the final goods on well-being. For instance, the impact of increase in price of fuel -consumed by households- on wellbeing. By the *indirect effect*, we refer to the impact of change in prices of the intermediate goods –used by producers- on wellbeing. For instance, if the increase in price of fuel induces some increase in price of transportation services. The impact of price increase in transportation on wellbeing is considered to be the indirect effect component.

The theoretical framework, presented above, enables to estimate the change in prices in the homogenous goods of the different economic sectors. In general, the disaggregation of economic sectors based on I/O or SAM matrices is different from that based on the main consumption posts in household surveys. For that reason, we have to perform the matching between the two structures, in order to estimate the change in prices of final goods. In this paper, we propose a simple linear approach to assess the change in price of final goods. For instance, assume that the final good in household survey is *Food* and the two correspondent sectors in the SAM matrix are *Agriculture* and *Fish*. Thus, the change in price of *Food* is: $dp_{food} = s_{Agriculuture} dp_{Agriculuture} + s_{Fish} dp_{Fish}$ and where s_x refers simply to total product share of x. Once the prices changes are estimated, the direct and indirect impacts on wellbeing can be estimated.

[2] See Lee (2002).

$$dW_h^{dir} = -e_{l,h} dp_l^{dir} \tag{9}$$

$$dW_h^{ind} = -\sum_{i=1}^{n} e_{i,h} dp_i^{ind} \tag{10}$$

3 Empirical application and the *pciom* Stata module

Our aim is to simulate an increase in the petrol products in Tunisia on the rest of goods. For that objective, we use 2010 Tunisian SAM matrix, with a level of disaggregation of 49 economic sectors. In table 1, we show the I/O matrix (49*49). The last line of the table contains the value added by sector. We omit, some sectors in a column way for editing page space. Thus, basic information that we need in the $(n+1)*n)$ matrix and where we find in line (n+1) of this matrix the value added. For simplicity, we assume that are price of the sectoral homogenous goods are normalized before the introduction of price chock. Based on this, we simulate an increase of 10% in price of petroleum products (branch: *D23*). The figure 1. As we can observe, those sectors with intensive use of the petroleum products experience the highest increases in prices of their products. While the proposed propose preserves the initial price petroleum chock, the Liontief approach implies a huge adjustment on that price. Of course, the pertinence of each method depends mainly on the context of the empirical study. In the case of small country that cannot affects largely the world price, or in general with a high rigidity of price adjustment price, the proposed linear approach can be the appropriate one.

To assess the impact on wellbeing, we use in general, the information of the usual expenditure household surveys. However, even by considering the main consumption posts the later do not have the same composition of the that of the I/O matrix. Thus, at this stage, we have to perform a matching as was presented in table 2. For instance, the I/O sectors that are devoted to the production of food or food industry that the economic sectors, in lines 1,2,4 and 5 of the I/O matrix. By using the simple a weighted mean estimator, we report in the last column of table 2 the price changes that can be used to assess the direct and indirect impacts of wellbeing. At this stage, we can start to introduce the Stata pciom module. Mainly this module, estimates the price changes with linear and Liontief approach. It enable also to estimate the price change in the main post consumption based on matching information. To lunch the dialog box of this application, type the command line: db pciom. After that, the following windows appears:

Mainly, have to open a file with at least one variable indicating the code of sectors of the I/O matrix. Of course the Number of observation of must equal to the number of sectors of the IO matrix. The use have to indicate also the filename of the datafile that contains the I/O matrix. The this file must contains $n + 1$ observations and n columns. In the last observation, we have to report the value added of each sector. Thus, this datafile is practically similar to what was reported in table 1. To simulate the impact of an exogenous price of given sector on the prices of the rest, the use have to indicate the position or number of line that corresponds to the sector concerned by the change and the level of price change in percentage. this is the minimum information to perform the estimation. Once the estimation is run, two new variables (_PRC1 and _PRC2) are created. These two variables contains the estimated price changes based

Figure 1: Estimated price changes (in%)

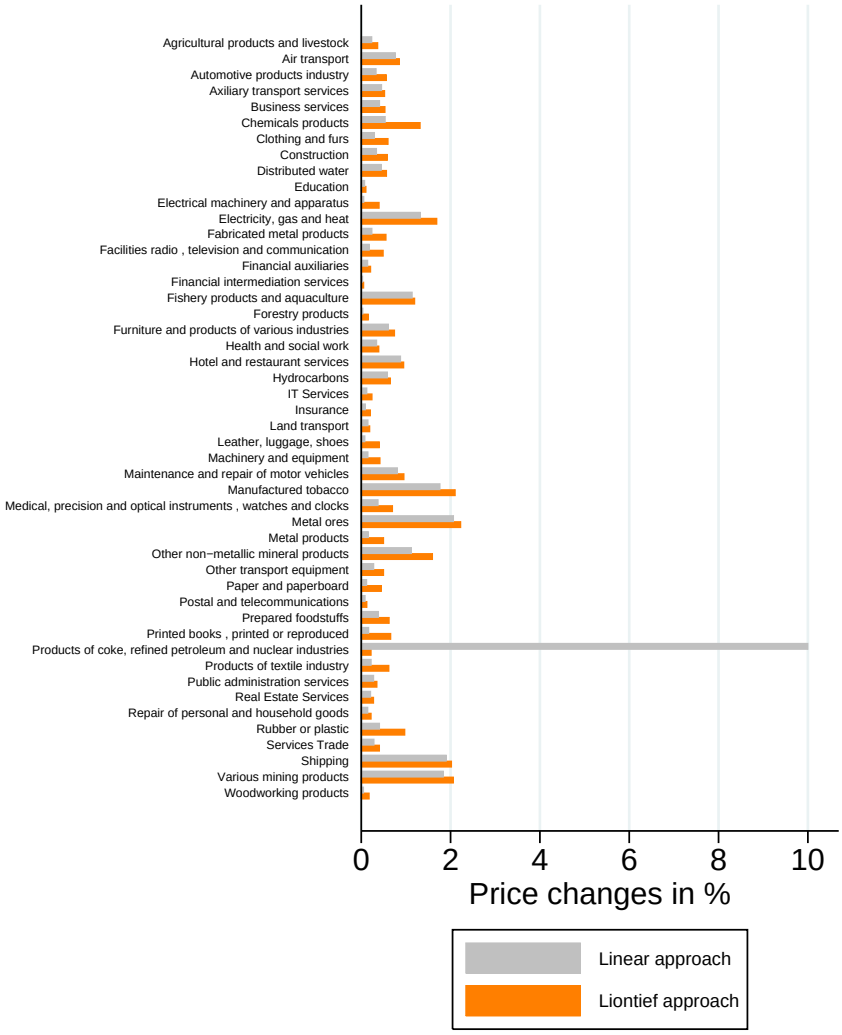
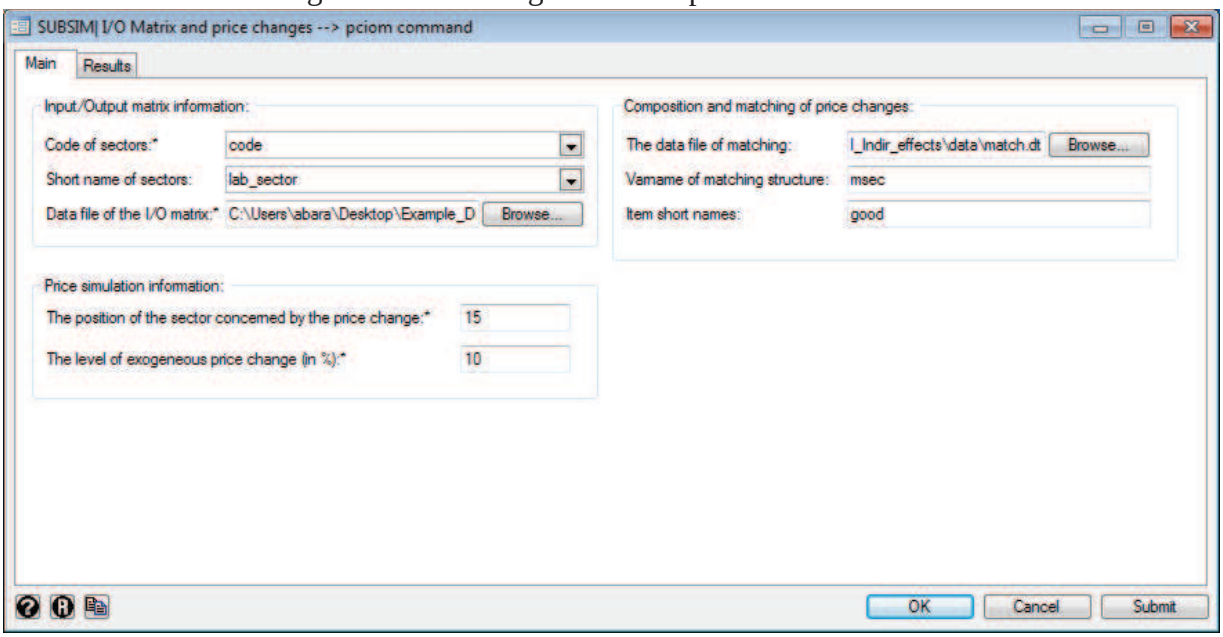
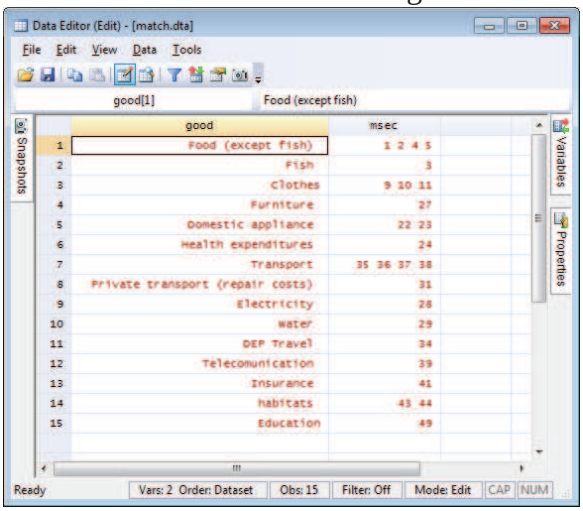


Figure 2: The dialog box of the pciom Stata module



on the linear approach and that of the Liontief. If the user plans to estimate the change in main the consumption posts, he must indicate the information about the matching structure. This information is supposed to be stored in another independent data file (the datafile match.dta in our example) that takes the following form:

Figure 3: The content of the matching data file example



	good	msec
1	Food (except fish)	1 2 4 5
2	Fish	3
3	Clothes	9 10 11
4	Furniture	27
5	Domestic appliance	22 23
6	Health expenditures	24
7	Transport	35 36 37 38
8	Private transport (repair costs)	31
9	Electricity	28
10	Water	29
11	DEP Travel	34
12	Telecomunication	39
13	Insurance	41
14	habitats	43 44
15	Education	49

Once we run the execution with this additional information of matching, a new variable of price changes is created in the marching datafile (match.dta). Of course, the price changes are estimated now for the different main post consumptions. As we can remark starting from the results reported in table 2, In addition to the transportation services, it seems that the price food products depends significantly on prices of the energetic products.

4 Conclusions

Price changes of some basic input, like the petroleum products, will affect the household wellbeing at two levels. The first is the *direct effect* and it is related to the intensity of direct consumption of the energetic products, like the gasoline for cars. The second is the *indirect effect* and it depends on the subsequent change in the rest of goods, which is implied by the change in energetic products, as inputs. Our main objective in this paper was to develop a simple linear method that can capture the bulk part of the impact, and this, without being embedded in the details of the interactions. Even if the proposed approach is linear, the latter can be easily applied, and it do not requires a lot of information. Of course, this is an essential criteria to answer quickly in order to highlight the policymakers about the impact of observed or simulated price changes. In this paper, we have developed a linear method to assess the change in prices in goods of the different sectors implied by a change in price of a given sector. Our main assumption is the exogenous nature of price change for the concerned sector even, in the ex-post stage. This assumption is more realistic when the country is a net importer of the good concerned by the price chock, (the petroleum products for instance). Finally, the results of empirical application with the Tunisian 2010 SAM matrix shows that the change in prices estimated with the linear approach are close to those based on the Liontief model. Further, the results show the non neglected impact of the energetic price changes on food products.

References

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Table 1: Add caption

Code	1	2	5	11	13	14	67	70	71	72	74	75	80	85
1	248010	0	48	0	0	0	0	0	0	0	36441	11830	6257	0
2	37186	477	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	872	0	0	0	0	0	0	0	7	7	3	0
11	148	0	1056	138727	0	0	0	1624	514	1707	7197	3287	4465	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	2147	0	44645	0	0	0	15	0	0	0	450
15	871229	0	64	0	0	130	11	0	0	0	34615	41745	30516	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	201	0	20	0	0	0	0	0	0	14	973	0	653	0
18	1	0	174	0	0	0	150	462	0	24763	148210	7677	24289	0
19	0	0	0	0	0	0	0	0	0	568	0	0	0	0
20	3	4032	0	131	0	915	0	0	0	615	1	0	0	0
21	129	0	31	78	0	15	1063	72	1238	40704	12651	2308	1619	7
22	6	0	171	0	0	100	1125	1683	591	4639	40475	14227	3980	0
23	103642	0	46379	242009	691	177562	18493	33307	1256	13548	125293	21345	25152	9040
24	241493	10906	1665	20559	46	19693	393	157	215	43875	38636	581	53918	714
25	24450	0	136	18475	0	6604	0	4881	0	6323	577	0	70	0
26	94	0	0	2209	0	8189	0	0	0	166	3896	175	94	5217
27	17	0	0	2239	0	4081	0	0	0	0	443	0	129	213
28	66	209	339	6074	0	1375	18084	147	61	3510	18649	13358	4632	655
29	21230	0	16	872	0	100	0	12	71112	201974	16880	0	0	321
31	0	0	584	86	86	16300	107361	0	0	27682	25889	6089	19107	0
32	8	0	0	0	0	0	0	0	0	0	3694	0	0	0
33	1470	0	0	0	0	0	4936	257	392	816	21080	800	4981	0
34	426	0	35	0	0	2502	0	0	0	1049	7713	0	0	3389
35	20	0	13728	0	0	0	0	0	0	0	2977	0	0	0
36	31	0	230	2374	0	17574	14648	1502	1266	11845	56282	7266	3337	558
40	5255	118	526	76786	843	54395	42064	7441	358	9097	67894	38709	16595	396
41	7801	0	45	1092	0	918	3655	25	2532	5920	4867	1401	938	26207
45	2494	0	0	67344	0	0	5298	0	6115	9962	5850	1899	1372	0
50	0	0	44	0	0	5118	49025	1889	0	2939	2400	7634	3785	5
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	69814	4505	2418	0
60	100	1	23	174108	0	117738	10859	195	65	3345	92648	8161	2193	117
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	108	77	1008	30921	1	2136	13884	1118	1729	14124	11405	3899	4115	305
63	0	0	0	0	0	0	0	804	16479	0	35890	0	0	0
64	443	276	3579	64963	3	8827	66946	7540	4004	76272	188870	31852	27946	2750
65	574	66	2	12326	1	8546	8822	4434	4256	8458	29300	1743	2796	203
66	1138	0	3430	14167	185	8324	85721	461	832	11445	267	13163	9995	215
67	905	0	1041	0	0	1774	26843	117	0	1218	9353	219	3013	56
70	1676	53	6373	51034	11	44587	2854	24715	3781	21145	64682	23317	30615	1189
71	1567	2	1	3531	0	7095	1088	940	44	5212	21443	3448	6990	27
72	0	0	0	0	0	0	0	0	2547	48324	50156	11439	7779	0
74	2729	33	8023	38648	6	23596	77431	2029	838	25538	211372	5247	37840	593
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	491	0	1369	0	0	0	0	0	1663	5381	2669	0	0	0
85	0	0	0	0	0	0	0	0	0	0	20713	0	12081	0
Value added	**4.00E+06**	**82454**	**323987**	**3.50E+06**	**2008**	**452014**	**1.70E+06**	**996395**	**189560**	**1.20E+06**	**2.30E+06**	**814618**	**4.10E+06**	**258114**

Table 2: Add caption

Main post consumptions	Matching structure	dp(Linear) (in %)	dp (Liontief) (in %)
Food (except fish)	1 2 4 5	1.083	1.203
Fish	3	1.142	1.197
Clothes	9 10 11	0.196	0.535
Furniture	27	0.609	0.746
Domestic appliance	22 23	0.120	0.448
Health expenditures	24	0.378	0.701
Transport	35 36 37 38	0.818	0.897
Private transport (repair costs)	31	0.810	0.958
Electricity	28	1.322	1.693
Water	29	0.449	0.567
DEP Travel	34	0.881	0.952
Telecommunication	39	0.087	0.127
Insurance	41	0.095	0.206
habitats	43 44	0.210	0.276
Education	49	0.346	0.395