BUILDING OF PRICE AND INCOME MODELS FOR UKRAINE USING SYSTEM DYNAMIC METHOD

Price model: The main target of the model is an inflation. The model shows how different parameters such as GDP, Labor and Import, price index, markup index and cost index causes changes in inflation. We can investigate how changing of one parameter effects inflation and all model in general. Here the main goal is to make Theil statistic test, Sensitivity analysis test, put the model in the equilibrium using real data for our country. Make some conclusions about how different parameters and shocks (step function) change the model and behavior of the model. Price model is represent on the Figure 1. For the model, we used quarterly data from 2012 to 2016 that was received from ukrstat.gov.ua or web page of national bank of Ukraine.



Figure 1. System Dynamics Model of Price

In this Price model, we are interested in behavior of inflation. We can change inflation only by changing price index and time to average inflation. In our model we can find inflation from formula: "100*SMTH1(Δ _price index/Price Index; time to average inflation)". Here we used SMTH1 function because changing inflation percentage it's not what happened instantly, it need some time to be done, it have

some delay. If we want to change price index, we need to have data for Labor cost (what is wages), real GDP and Capital. It's impossible to find data for capital, so we calculate it. GPD it's Labor + Capital, so from that we received: Capital=GDP-Labor. When we know all initial values, we can calculate domestic unit costs, what is (labor + capital)/GDP, it must be equal to 1. Also we need to calculate WT of import cost=real import to UA/(real import to UA+GDP). WT it's some weight for calculating cost index.

Cost index= SMTH1((wt_of_import_cost*unit_import_costs_US) + +((1-wt_of_import_cost)*domestic_unit_costs);time_to_avg_costs).

Here we use also SMTH1 function, because in real life exist delay. Next step we can calculate Δ price index = (Markup index*cost index-Price index)/price adj time.

When our model is in equilibrium, inflation=0, price index=1, Δ price index=0 because

(Markup index(=1)*cost index(=1)-Price index(=1))/price adj time(=0,25)

so 0/0,25=0. Also in equilibrium when we do step function in time 2014, we increase wages, we will see dynamic represented by Fig. 2.



Figure 2. Impact of wage increase on Price Index

It's natural reaction, because when we increase wages, our capital and GDP is still the same and we would not receive 1 in domestic unit costs, this value will be higher, as a result we will have higher cost index, and as a result, price index will increase. Sometimes it's impossible to find some data for initial values, for example, average life of capital or capital of all country, so we calculated them. In addition, some quarterly data have seasonality and by using Evievs software, we make them unseasonal for better fitting to our model and correct work of equations in Stella Architect. Also, we need to deal with the fact that sometimes it's hard to collect data in Ukraine after 2014 because of occupation of Crimea peninsula and war in the east part of Ukraine. Data was collecting for such parameters: Real Import to UA, Unit import costs UA, Wages, GDP, interest rate, inflation, real expected demand, demand elasticity of markup. Capital calculated according to Labor costs and GDP. Time to average inflation and average life of capital founded using sensitivity analysis test and Theil statistic. According to our investigation, the best fit was when average life of capital was 14 years and time to average inflation was 1 month.

MSE for our model is 21,8

RMSPE is 50%

	Table						Table				
	2012	2013	2014	2015	Final		2012	2013	2014	2015	Final
Run 1: MSE	1,0	2,3	1,2	29,0	21,8	RMSPE	0,0	0,5	0,4	0,6	0,5

We have big covariation error 60%, Bias 31% and Variation error 9%.



Figure 3. Decomposition of Theil statistics for Price model

Income model: In this model, the main goal is to know how parameters such as wages and aggregate demand, percent of business tax and percent of private tax will influence the collected taxes. Here our task is also make Theil statistic test, sensitivity analysis test, put model in the equilibrium to know how different parameters and shocks (step function) change the model and behavior of this sub model, make some conclusion from received data and behavior. Income model is represented on Fig. 4.

In Income model our taxes is sum of personal taxes and business taxes. Personal taxes is the sum of wages and dividends multiplied by personal tax percent (in Ukraine it is 18%), to be clear with - it's just how much taxes you will pay when you receive salary. Disposable wages & dividends = wages + dividends – personal taxes, it's our profit. Taxes pay not only average person who work, but also and business, and in our model business taxes it's a stock and formula for that is next:

MAX(0;business_tax_pct*SMTH1(operating_surplus;time_to_avg_operating_surplu s; initial operating surplus)).



Figure 4. System Dynamics Model of Income

Business tax percent =18%, operating surplus it's difference in aggregate demand (AD) and wages, time to average operating surplus it's 3 month and initial operating surplus it's real data. Here we use MAX between 0 and formula is to avoid addition of negative number. In equilibrium parameters like personal pct and business pct cause effect on our model, such as increasing or decreasing taxes. If percentage is higher so more taxes we will collect, the same is with wages, if we want to increase our budget we can make higher taxes, what actually our government did in 2015 and also add one more military tax in 2014, what help to increase budget.

When we will make step in wages and we will increase our wages in 2014.



Figure 5. Impact of wage increase on Taxes

We will see that it can have negative effect, because if we will increase wages, we will have more profit from personal taxes, but business taxes will decrease. Data founded for next initial values: wages, aggregate demand business tax percentage, personal tax percentage, initial operating surplus. Also we found disposable wages & dividends data and taxes real data. It's very hard to found data for business saving, so we calculate them. Business saving= taxes-disposable wages. For sensitivity analysis we chose dividend percent = 0,33 %, as a result.



Figure 6. Dynamics of factual and fitted values of Taxes

Our graph show almost perfect fit to real taxes data.

Our MSE error and RMSPE:

Table											
	2012	2013	2014	2015	Final						
Run 1: MSE	1,0	65,9M	334,8M	255,1M	1,3B						
Run 1: RMSPE	0,0	0,0	0,1	0,1	0,1						

RMSPE is only 10% what is pretty good result.



Figure 7. Decomposition of Theil statistics for Income model

Covariation is 15%, variation is 82%, bias is 3%.

In conclusion we can say that our models work correct, it show us real behavior of our inflation and taxes but it's hard to collect data, or data didn't show reality, for example wages, a lot of companies show to government that they pay minimum salary, to avoid paying taxes. We analyzed problem of formulating inflation and collecting taxes in our country. Realized that every parameter in our sub models have big influence on inflation and taxes.

References

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