

The use of system dynamics in project activities in the process of teaching physics increases the level of understanding of the laws physics, allows students to master the method of scientific knowledge, develops physical thinking, communicative competence. Involving school students in research and exploration activities contributes development of their cognitive interests.

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RELATIONSHIP BETWEEN PRICE AND WAGE IN UKRAINE: SYSTEM DYNAMIC EVALUATION

The subject of our research is to take a closer look at the relationship between wages and prices, in case of Ukraine. By view of Ricardo, prices are determined by wages. Broadly speaking, prices are determined by cost of production, while cost of production is determined by cost of labor.

Our work is an application of MacroLab to the Ukrainian economy. MacroLab was developed by Professor David Wheat at the University of Bergen.

The relationship between wages and prices in model is described in the following way:

$$\text{Average Wage}_t = \text{Average Wage}_{t-1} + \Delta \text{average wage} * DT \quad (1)$$

$$\Delta \text{average wage} = \text{Average Wage} * \text{delayed wage growth rate} \quad (2)$$

$$\text{Unit labor hour cost} = \frac{\text{Average Wage} * \text{over time effect}}{\text{labor hour productivity}} \quad (3)$$

$$\text{Desired price index} = \text{unit labor hour cost} * (1 + \text{mark up}) \quad (4)$$

$$\text{Price index}_t = \text{Price index}_{t-1} + \Delta \text{Price index} * DT \quad (5)$$

$$\Delta \text{Price index} = \frac{\text{desired price index} - \text{Price index}}{\text{price adj time}} \quad (6)$$

$$\text{Inflation} = 100 * \text{Trend}(\text{Price index}, DT, \text{initial inflation}) \quad (7)$$

$$\text{wage growth rate} = \text{SMTH1}(\text{inflation} / 100 + \text{labor productivity growth rate}, 0.25) \quad (8)$$

$$\begin{aligned} \text{delayed wage growth rate} = \\ = \text{Delay1}(\text{indicated wage growth rate}, \text{wage adj delay}) \end{aligned} \quad (9)$$

The basic logic included in equations (1) - (9), is that if the average wage of an economy increased it would cause consumers within the economy to purchase more product, which would increase demand. The rise in demand and the increased wage burden causes businesses to increase the prices of products and services. Although wages are higher, the increase in prices causes workers to demand even higher wages. If higher wages are granted, a spiral where prices subsequently increase may occur repeating the cycle until wage levels can no longer be supported.

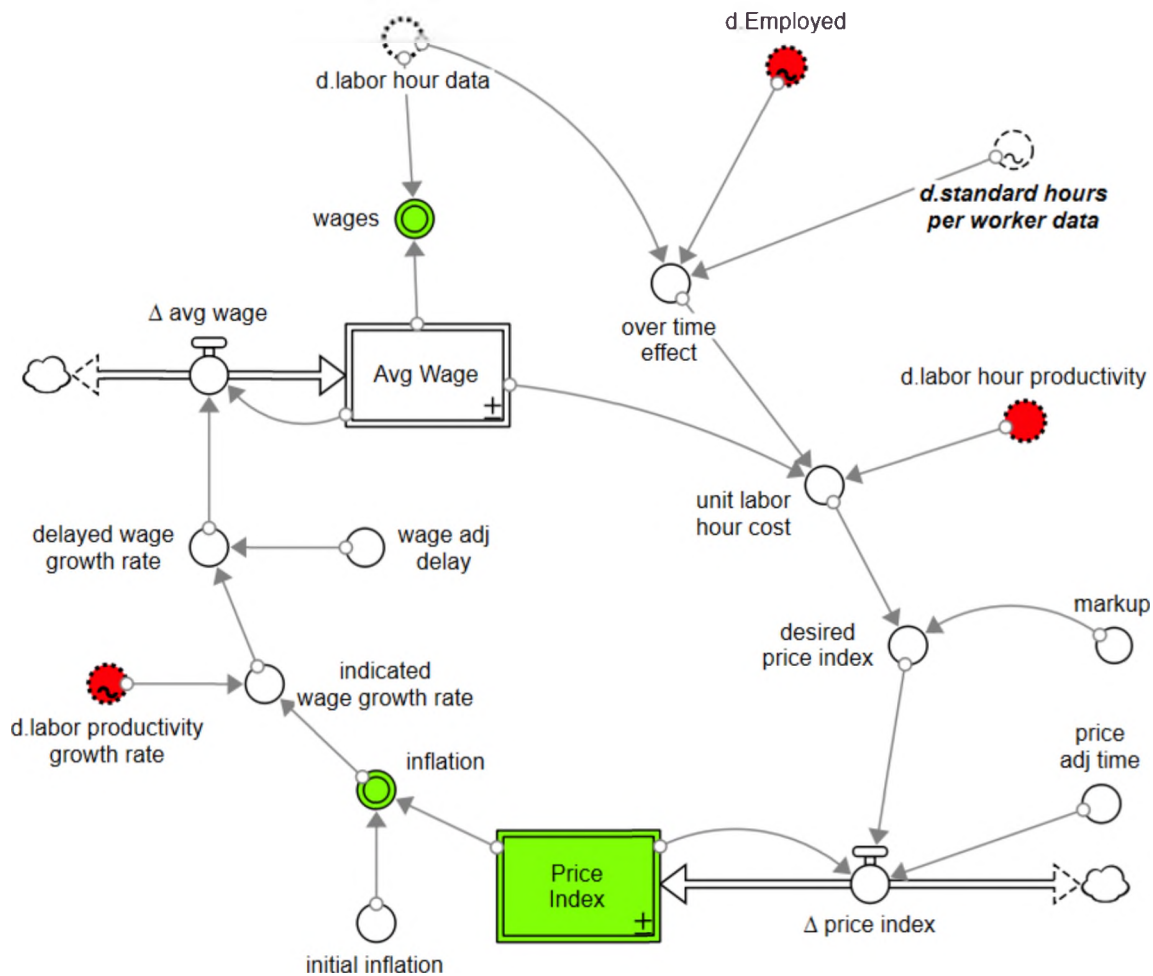


Figure 1. Price and Wage Model

Here we pay our attention to inflation development in Ukraine economy. High inflation in the economy means that the purchasing power of consumers falls as they are no longer able to purchase the same amount of goods and services with the same amount of money, so inflation has the inverse effect on the well-being of population.

Behavior of the historical and simulated Price index is presented on the Figure 2. The sustainable growth of Price index in 2015 can be explained by military aggression in the east of Ukraine and currency crisis.

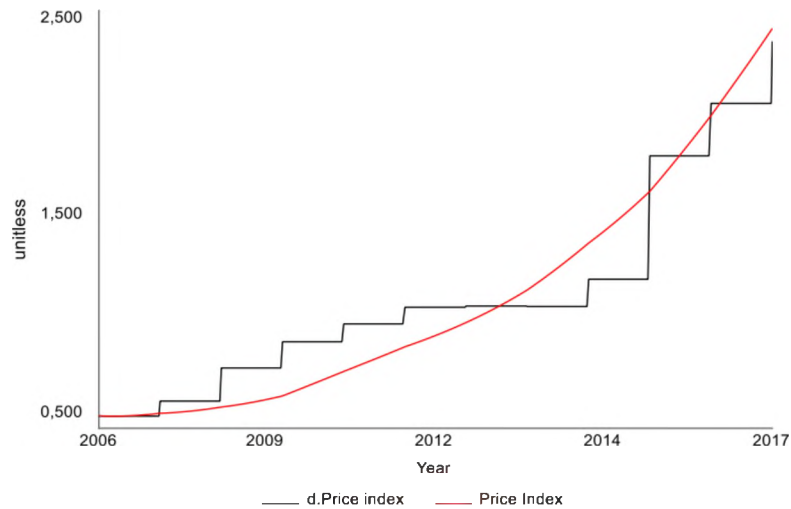


Figure 2. Simulated & Actual Price Index

Using Theil statistics, we assess the model’s ability to reproduce the historical data of the Ukrainian economy, in other words, its accuracy and performance. The RMSE range is from 0 to 20 percentage points (Figure 3). The largest deviation of simulated consumer price index from actual data is observed during the World crisis (2008-2009), also substantial deviation is observed during “perfect storm” in Ukraine (2014-2015). In general, simulated behavior is close to observed one in Ukrainian economy.

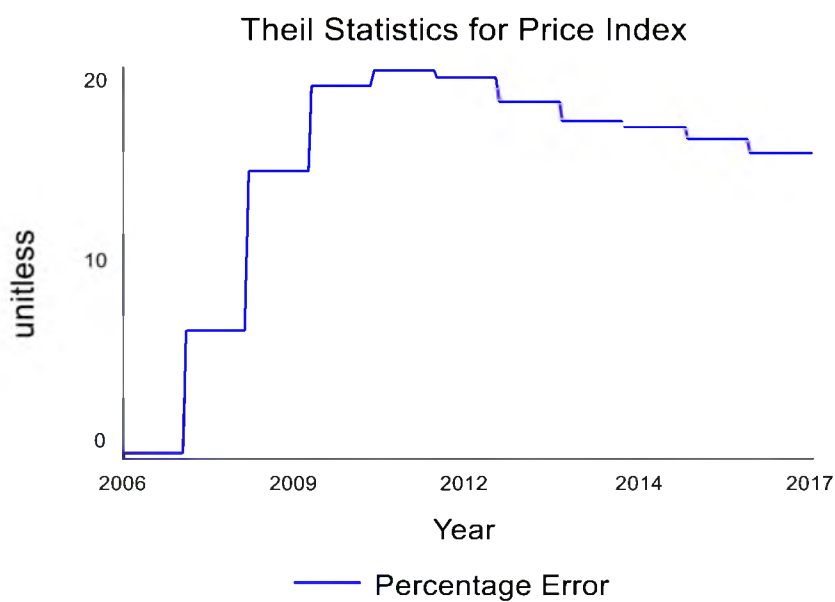


Figure 3. RMSE of Theil Statistic

We have the assumption, accompanied by our observations in Ukraine, that employees do not work certain number of hours that is established by law (8 hours), since some employees may work part time and some overtime. Thus, we consider two cases:

- employees work overtime (average 9 hours per day);
- employees work undertime (average 6.5 hours per day).

In first case to get good matching simulated data with historical, we get more suitable mark up = 1 due to optimization.

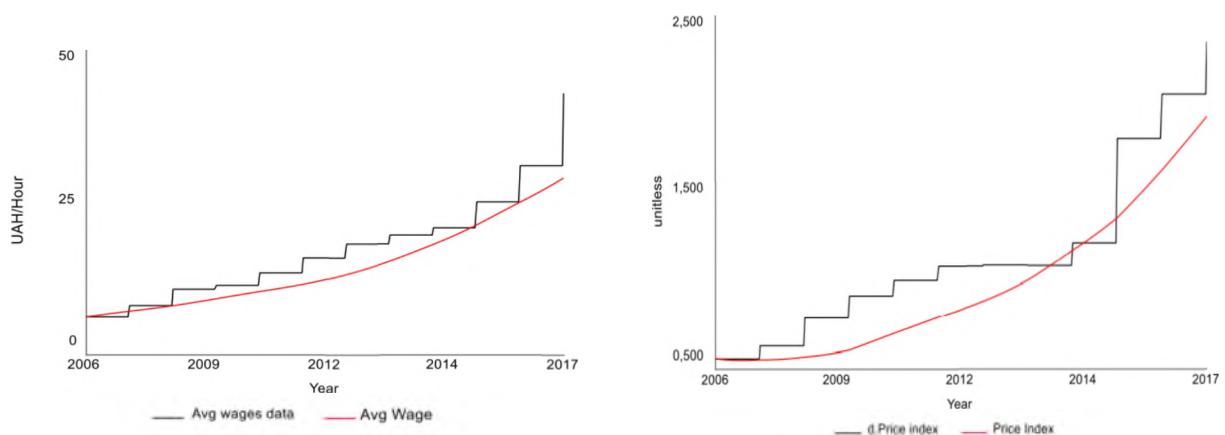


Figure 4. Overtime working day: average wages and price index

In second case, in order to achieve good fit between simulated and historical data, we get mark up = 1.85.

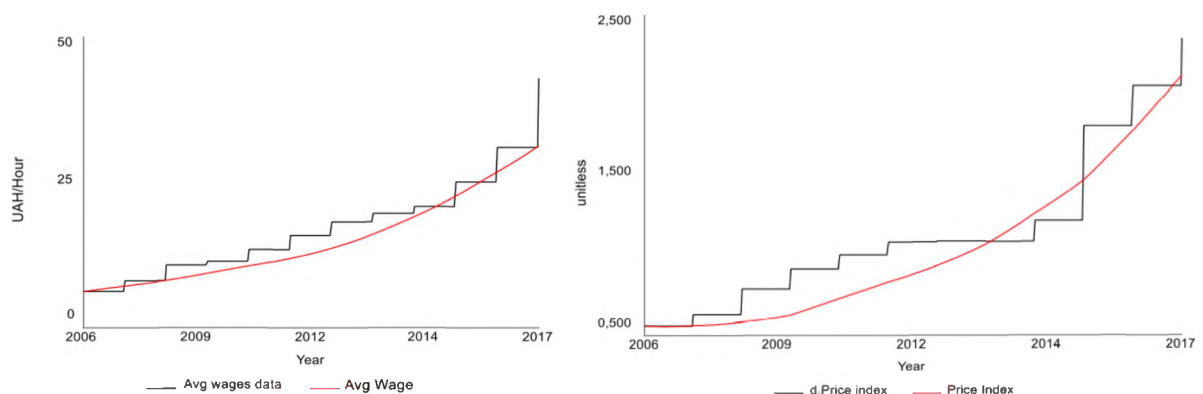


Figure 5. Undertime working day: average wages and price index

So, as we can see when employees spend extra time working in addition to standard working hours or less then it affects unit labor cost, and as result this affect price index and in turn on wages.

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SYSTEM DYNAMICS MODEL FOR CAPITAL AND PRODUCTIVITY IN UKRAINIAN ECONOMY

Capital and productivity is a part of supply side model that shows how efficiently capital is used to generate output. It reflects the joint influence of labour input per unit of capital used and multifactor productivity (reflecting the overall efficiency of production). Investment in information and communication technologies in particular enables new technologies to enter the production process and is seen as an important driver of productivity growth. This model help you to learn about structure and performance of the Ukraine economy.

The main factors which we used in our model are: labour productivity, capital, real investment, employed, technology etc. Also for this model we used such Ukrainian historical data for the period from 2006 to 2017: employed, initial labor productivity, average standard hours per worker, initial active capital labor ratio and normal capital utilization.

Let us start with *the labor productivity*. Labor productivity measures the hourly output of a country's economy. Specifically, it charts the amount of real gross