

Analysis of the Czech economy development based on IS-LM model.

(The impact of CNB interventions in 2013-2016 on the Czech economy in IS-LM model.)

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Abstract

The main topic of article is the description of IS-LM model on real data of the Czech economy for the years 1999 - 2016. The IS-LM model is simplified to the linear equations of IS and LM functions. The statistical data of the Czech economy for years 1999 - 2016 was used for deriving of equations parameters for IS and LM straight lines. This model is used for modelling the impact of CNB's interventions to depreciate CZK against EUR into the Czech economy. The results are pressure to lower interest rates theoretically to negative values, and unproductive "dead" money was lying unnecessarily in the accounts. The CNB's intervention did not lead to a strengthening the growth of foreign trade balance. The CNB's interventions did not lead to an increase in household consumption. To the recovery of the Czech economy in 2014 and 2015 an increase in investor activity helped. CNB's interventions did not have a direct effect on the inflation growth in the Czech economy.

Shrnutí

Hlavním cílem tohoto článku je výpočet parametrů IS-LM modelu zjednodušeného do přímek na základě reálných výsledků české ekonomiky v letech 1999 – 2016. Takto vypočtené parametry rovnic přímek IS a LM byly použity pro modelování dopadů intervencí ČNB za oslabení koruny v letech 2013 – 2016. Z provedených výpočtů jednoznačně vyplývá, že tyto intervence ČNB tlačily úrokové sazby až do negativních hodnot a že v jejich důsledku ležely „mrtvé“ peníze na účtech. Intervence ČNB nevedly k růstu bilance zahraničního obchodu ani růstu spotřeby domácností. Tyto intervence neměly ani přímý vliv na růst inflace v české ekonomice. K oživení české ekonomiky v letech 2014 a 2015 vedla zvýšená aktivita investorů.

Key words:

IS-LM model, Czech National Bank, Intervention, GDP, Economic crisis, Czech economy

JEL: C30, C32, E58

Introduction

The Czech economy is undoubtedly one of the most successfully transformed economies in Central and Eastern Europe. Czech economy can be considered as a market economy without significant intervention by state institutions since 1999. However, this cannot be said about the development of the Czech economy between the end of 2013 till 2016 when the Czech National Bank (CNB) intervened in the depreciation of the CZK/EUR exchange rate. From the standpoint of central banking practices, the CNB's actions can be considered as non-standard and unusual.

The aim of this article is to calculate the parameters of the IS-LM model on the basis of statistical data for the development of the Czech economy in the period 1999-2013 and on the basis of this calculated model to obtain an alternative view on the development of the Czech economy at the time when the CNB intervened in the CZK's depreciation.

The IS-LM model gives the relationship between the interest rate (i) and the gross domestic product (Y) according to professional literature in the short-term future. The equilibrium state of the economy occurs at the point of intersection of functions representing the balance of investments and savings (IS function) and the balance of supply and demand for money (LM function). The derivative of the above-mentioned function is a mathematically complex task, based on a statistical evaluation of the historical data on the development of a given economy that may not have a solution in the real world. For this practical reason, IS and LM functions are generally considered as a straight line. The axes of charts on which this equilibrium and its displacements are explained, they are not usually marked to scale, see Chart 1. The description of the shifting of the intersections of the IS and LM straight lines with the y -axis (so-called shifts of the straight lines to the left or to the right) and the description of the changes in the slope of these IS and LM straight lines could be mostly considered as the alchemical instructions for gold production rather than a description of the mathematical model.

Example of the usually presented IS-LM chart without scaled axis:

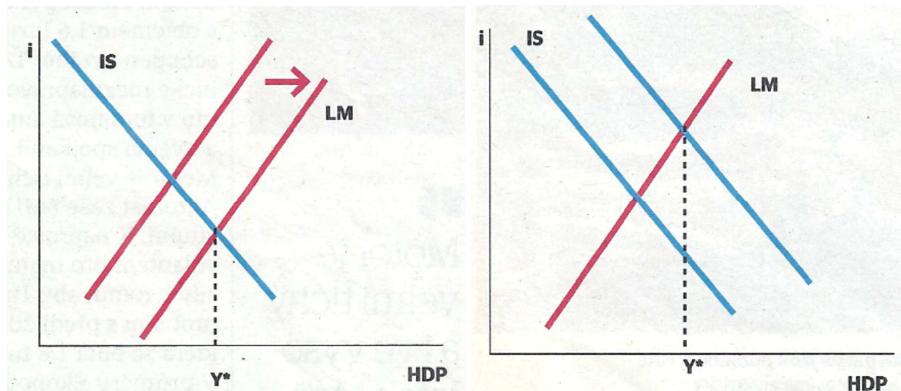


Chart 1 [2]

Theory - a brief summary of the IS-LM model and the derivation of the formulas used for calculating its parameters.

For the transparency of the IS-LM model parameters' calculations is considered as important to derive the mathematical formulas for the straight lines expressing the function IS and function LM in the coordinates Y and i .

First of all, given the fact that the mathematical model of the above described relations uses the simplification of functions to the straight lines it must be noted that this simplification can only be applied with a certain degree of accuracy to the limited interval ΔY and the corresponding interval Δi . The interval's location on the axis x and axis y and its width with respect to the required accuracy cannot be determined because it is unknown the real mathematical correlation between investments and savings and between supply and demand for money in the real living economy.

Deriving an IS straight line function [4]:

Because it was simplified the IS-LM model functions to straight lines, it must be consistently based on the dependencies among appropriate variables in the form of the straight line equation.¹

Therefore, it is expressed the household consumption by the equation of the straight line:

$$C = \bar{C} + cY \quad [\text{CU}] \quad (1)$$

The symbols' meaning:

C – household consumption; [CU]

\bar{C} – autonomous household consumption (exogenous variable, theoretical consumption for $Y = 0$); [CU]

c – marginal propensity to household consumption, (exogenous variable); ($0 \leq c \leq 1$); [-]

Y – Gross Domestic Product (GDP); [CU]

It is expressed the investment by the equation:

$$I = \bar{I} - bi \quad [\text{CU}] \quad (2)$$

The symbols' meaning:

I – investment; [CU]

\bar{I} – autonomous investment; (exogenous variable, theoretical investment for $i = 0$); [CU]

b – Interest rate sensitivity of investment, (exogenous variable); [CU]

i – interest rate; ($i = r/100$, where r is mark for interest in %); [-]

It is expressed the import by the equation:

$$NX^{im} = \overline{NX^{im}} - nx^{im} x \quad [\text{DCU}] \quad (3)$$

The symbols' meaning:

NX^{im} – import at current exchange rate DCU/FCU; [DCU]

$\overline{NX^{im}}$ – theoretical import at exchange rate DCU/FCU=0, (exogenous variable); [DCU]

nx^{im} – import change coefficient when changing DCU to FCU by 1 DCU, (exogenous variable); [-]

x – current exchange rate DCU/FCU; [DCU]

Similarly it is expressed the export by the equation:

$$NX^{ex} = \overline{NX^{ex}} + nx^{ex} x \quad [\text{DCU}] \quad (4)$$

The symbols' meaning:

NX^{ex} – export at current exchange rate DCU/FCU; [DCU]

$\overline{NX^{ex}}$ – theoretical export at exchange rate DCU/FCU=0, (exogenous variable); [DCU]

nx^{ex} – export change coefficient when changing DCU to FCU by 1 DCU, (exogenous variable); [-]

x – current exchange rate DCU/FCU; [DCU]

The meaning of exogenous variables is explained below:

The marginal propensity to household consumption (c) is a dimensionless number from the interval $0 \leq c \leq 1$ which indicates how much household consumption will increase when gross domestic product rises by one CU and vice versa. The autonomous household consumption (\bar{C}) in the linear model indicates the theoretical household consumption for zero GDP.

Interest rate sensitivity of investment (b) is the number expressed in currency units. The value $b/100$ indicates how much the amount of investment will fall, in case an interest (r) will increase by 1 % and vice versa. The autonomous investment (\bar{I}) in the linear model indicates the theoretical investment for zero interest (r). In practice \bar{I} can be interpreted as a measure of investor's willingness to invest under given economic and political circumstances.

Import change coefficient (nx^{im}) indicates how much the import decreases when the FCU price rise by 1 DCU (depreciation of the DCU), and vice versa. The value $\overline{NX^{im}}$ is the theoretical import for the exchange rate DCU/FCU equal to 0.

Export change coefficient (nx^{ex}) indicates how much the export increases when the FCU price rise by 1 DCU (depreciation of the DCU), and vice versa. The value $\overline{NX^{ex}}$ is the theoretical export for the exchange rate DCU/FCU equal to 0.

¹ In the following text, we will generally mark CU - any Currency Unit, if necessary we will differentiate DCU - Domestic Currency Unit and FCU - Foreign Currency Unit.

Into the equation for gross domestic product [3]

$$Y = C + I + G + NGO + NX \quad [\text{CU}] \quad (5)$$

The symbols' meaning:

G – government final consumption expenditure; (exogenous variable); [CU]

NGO – NGOs' final consumption expenditure (exogenous variable); [CU]

NX – the balance of foreign trade, we calculate from the formula $NX^{ex} - NX^{im}$ [CU]

The meaning of other symbols - see equations (1) to (4).

is putting equations (1) to (4) and we reach the following':

$$Y = \bar{C} + cY + \bar{I} - bi + G + NGO + (\bar{NX} + nx x) \quad [\text{CU}] \quad (6)$$

The symbols' meaning:

$\bar{NX} = \overline{NX^{ex}} - \overline{NX^{im}}$ [CU]

$nx = nx^{ex} - nx^{im}$

The meaning of the other symbols - see equations (1) to (5).

To express equation for the IS straight line, is needed to determine what is a dependent variable and what is an independent variable. However, in real life both situations can occur, i is dependent on Y and vice versa. Central banks sometime tend to reach change Y by influencing i . In view of the fact that in the professional literature it is usually present the gross domestic product (Y) as an independent variable on the x -axis and the interest rate (i) as a dependent variable on the y -axis therefore we derive IS straight line as the equation:

$$i = \frac{\bar{C} + \bar{I} + G + NGO + (\bar{NX} + nx x)}{b} - \frac{1-c}{b} Y \quad [\text{CU}] \quad (7)$$

The symbols' meaning - see equations (1) to (6).

From the equation (7) follows, that the interest rate sensitivity of investment (b) affects both the shifting intersection of the IS straight line with the y -axis and a slope of the IS straight line (its first derivative). The marginal propensity to household consumption (c) affects the slope of the IS line.

Basic accepted assumptions are:

Tax rate is for our model neutral. We are going from assumptions that the taxes are paid to public servants who spend them partly and thus C is increased and the government spends them within government spending framework and thus G is increased. We are assuming that taxes don't disappear in the black hole. For the calculations we use statistical data at current prices, thus we eliminate the errors caused by the price conversion methodology. We abstract from the possibility that the variables C, I, G, NGO and NX at time t depend on the past progress of GDP (Y) at time $t - 1$. The government's final consumption expenditure (G) and NGOs final consumption expenditure (NGO) are determined only by the government's and NGO's decisions and are independent of other variables of the IS-LM model (exogenous variable).

Deriving an LM straight line:

The demand for real money in the linear model is expressed by using the formula:

$$L = kY - hi \quad [\text{CU}] \quad (8)$$

The symbols' meaning:

L – demand for real money; [CU]

Y – Gross Domestic Product (GDP); [CU]

i – interest rate; ($i = r/100$, where r is mark for interest in %); [-]

k – GDP sensitivity of demand for real money (exogenous variable); $k \geq 0$; [-]

h – interest rate sensitivity of demand for real money (exogenous variable); (if h^* is a change of demand for real money by changed r of 1 % then $h = h^* * 100$); $h \geq 0$; [CU]

On the other hand, money supply M is given by the central bank desision (exogenous variable) and is constant in the short term (independent of i). For the equilibrium point, it must be valid:

$$M = L \quad [\text{CU}] \quad (9)$$

The symbols' meaning:

M - supply for real money; [CU]

L - demand for real money; [CU]

By combining equation (8) and (9) we reach the following:

$$M = kY - hi \quad [\text{CU}] \quad (10)$$

The symbols' meaning - see equations (8) and (9)

The meaning of exogenous variables is explained below:

GDP sensitivity of demand for real money (k) indicates how much the demand for real money is less than GDP (Y) for $0 \leq k < 1$, or equal/greater than GDP for $k \geq 1$. The fraction $1/k$ means how many times a year the amount of money (M) is rotated.

The interest sensitivity of demand for real money (h^*) to the interest (r) indicates how much demand for real money will fall with an increase in interest (r) of 1% and vice versa. We assume that if interest (r) increases, demand for real money falls, and economical entities will tend to invest money in various savings and investments products.

In accordance to the graph for the IS straight line, we choose as the independent variable gross domestic product (Y) - on the x -axis and as the dependent variable interest rate (i) - on the y -axis. After simplification, we get the equation for LM straight line in the form of:

$$i = \frac{k}{h} Y - \frac{M}{h} \quad [-] \quad (11)$$

The symbols' meaning - see equations (8) and (9).

From equation (11) it can be deduced, that the interest rate sensitivity of demand for real money (h) affects both the shifting intersection of the LM straight line with the y -axis and a also change of slope of the LM straight line (its first derivative). The GDP sensitivity of demand for real money (k) affects the slope of the LM line.

Application - Calculation of IS-LM model's parameters:

The input data for calculating the IS and LM straight lines for the Czech economy are taken from sources [6] – [14].

Table of input data used to calculate IS-LM model parameters:

	Y GDP [10 ⁹ CZK]	C households [10 ⁵ CZK]	G govern [10 ⁵ CZK]	NGO non-p. [10 ⁵ CZK]	I invest [10 ⁵ CZK]	NX ^{ex} export [10 ⁵ CZK]	NX ^{im} import [10 ⁵ CZK]	NX balance [10 ⁵ CZK]	i interest [CZK]	CZK/EUR	inflation	M1 money [10 ⁶ CZK]
year												
1995	1 578 636	769 041	313 744	10 883	533 927	639 626	688 585	-48 959	9,50%			424 900
1996	1 810 798	891 356	348 998	13 163	645 427	695 292	783 438	-88 146	10,50%	8,81%	447 100	
1997	1 950 707	996 566	390 175	14 748	630 260	790 472	871 514	-81 042	13,00%	8,63%	418 900	
1998	2 140 062	1 074 217	407 493	15 546	648 417	904 063	909 674	-5 611	11,50%	10,70%	404 000	
1999	2 231 080	1 130 808	444 846	15 008	649 290	956 764	965 636	-8 872	5,50%	36,88	2,20%	447 800
2000	2 374 292	1 191 614	462 089	16 016	748 717	1 148 113	1 192 257	-44 144	5,00%	35,61	3,72%	497 700
2001	2 564 082	1 270 540	499 695	14 766	811 377	1 260 355	1 292 651	-32 296	4,25%	34,08	4,70%	583 600
2002	2 673 696	1 325 143	559 769	15 635	807 284	1 209 434	1 243 569	-34 135	2,00%	30,81	1,85%	692 300
2003	2 800 145	1 390 139	611 669	15 833	816 182	1 317 737	1 351 415	-33 678	1,25%	31,84	0,13%	809 500
2004	3 052 035	1 479 812	634 137	18 523	894 579	1 748 247	1 723 263	24 984	1,25%	31,90	2,72%	1 026 300
2005	3 254 349	1 543 634	664 519	21 783	948 220	2 024 406	1 948 213	76 193	1,00%	29,78	1,89%	1 162 600
2006	3 509 544	1 631 817	699 718	24 447	1 057 348	2 292 746	2 196 532	96 214	1,25%	28,34	2,60%	1 325 600
2007	3 833 819	1 749 982	731 638	25 708	1 232 446	2 552 998	2 458 953	94 045	2,25%	27,76	2,77%	1 526 500
2008	4 010 776	1 885 707	765 513	26 330	1 246 851	2 537 501	2 451 126	86 375	2,50%	24,94	6,33%	1 874 800
2009	3 923 493	1 891 397	811 710	27 044	1 040 678	2 309 117	2 156 453	152 664	0,50%	26,45	1,10%	1 771 800
2010	3 949 318	1 918 560	809 674	27 140	1 072 399	2 609 184	2 487 639	121 545	0,25%	25,29	1,42%	2 021 700
2011	4 029 671	1 950 717	813 161	26 764	1 088 416	2 871 719	2 721 106	150 613	0,25%	24,59	1,94%	2 149 800
2012	4 058 949	1 970 042	804 078	27 346	1 057 858	3 094 549	2 894 924	199 625	0,25%	25,14	3,27%	2 336 300
2013	4 097 000	1 996 324	826 004	28 384	1 010 380	3 147 940	2 912 032	235 908	0,05%	25,97	1,43%	2 514 300
2014	4 312 534	2 044 021	849 155	29 378	1 115 698	3 558 577	3 284 295	274 282	0,05%	27,53	0,40%	2 803 300
2015	4 556 739	2 110 138	889 672	30 176	1 246 895	3 783 080	3 503 222	279 858	0,05%	27,28	0,30%	3 101 200
2016	4 712 869	2 183 454	915 431	31 128	1 236 088	3 784 290	3 437 522	346 768	0,05%	27,03	0,70%	3 422 800

Table 1 (CNB, CZSO and author)

As a basis for the calculation of IS-LM model parameters, statistical data was used for the Czech economy for 1999 to 2013 at nominal value. The CNB's discount rate for (i), the CNB's exchange rate CZK/EUR for exchange rate (x) and aggregate M1 for supply for real money (M) were used as the value of the input data. This period's data is considered to be representative of purely market developments in the Czech economy not affected by administrative intervention by state institutions. For the years 2014-2016 is considered the data to be affected by the CNB's administrative intervention in the development of the CZK/EUR exchange rate (depreciation CZK).

From a practical point of view, it is accepted the simplistic assumption that the parameters of IS and LM straight lines equations can be derived from the long-term data for the Czech economy development with a satisfactory degree of accuracy. It is calculated the straight line equations parameters by using the least squares method based on the above mentioned input data (Table 1).

The following parameters of equation (1) were calculated:

$$C = 121 + 0.447 Y \quad [10^9 \text{ CZK}] \quad (12)$$

The symbols' meaning - see equations (1)

Household consumption (C) generally shows a very close dependence to GDP (Y) expressed by a correlation coefficient equal to 0.993.

The following parameters of equation (2) were calculated:

$$I = 1 071 - 5 769 i \quad [10^9 \text{ CZK}] \quad (13)$$

The symbols' meaning - see equations (2)

The relation between I and i is characterized by a correlation coefficient equal to - 0.588.

Based on the statistical data for the years 1999 - 2013, is derived the following parameters for the IS straight line:

Item	Symbol	Value	Dimension
Autonomous household consumption	\bar{C}	121	[10^9 CZK]
Marginal propensity to household consumption	c	0.447	[$-$]
Autonomous investment	\bar{I}	1 071	[10^9 CZK]
Interest rate sensitivity of investment	b	5 769	[10^9 CZK]

Table 2 (author)

Then the equation for the IS straight line (7) will be in the form:

$$i = \frac{121+1 071+G+NGO+NX}{5 769} - \frac{1-0,447}{5 769} Y \quad [\text{CU}] \quad (14)$$

The symbols' meaning:

NX - the balance of foreign trade, for further calculations we consider NX to be an exogenous variable.

The meaning of other symbols - see equations (1) to (5).

In years 1999-2016, graphical representation of IS straight lines, for the changing exogenous variables $G + NGO + NX$ and for parameters according to Table 2 is as follows:

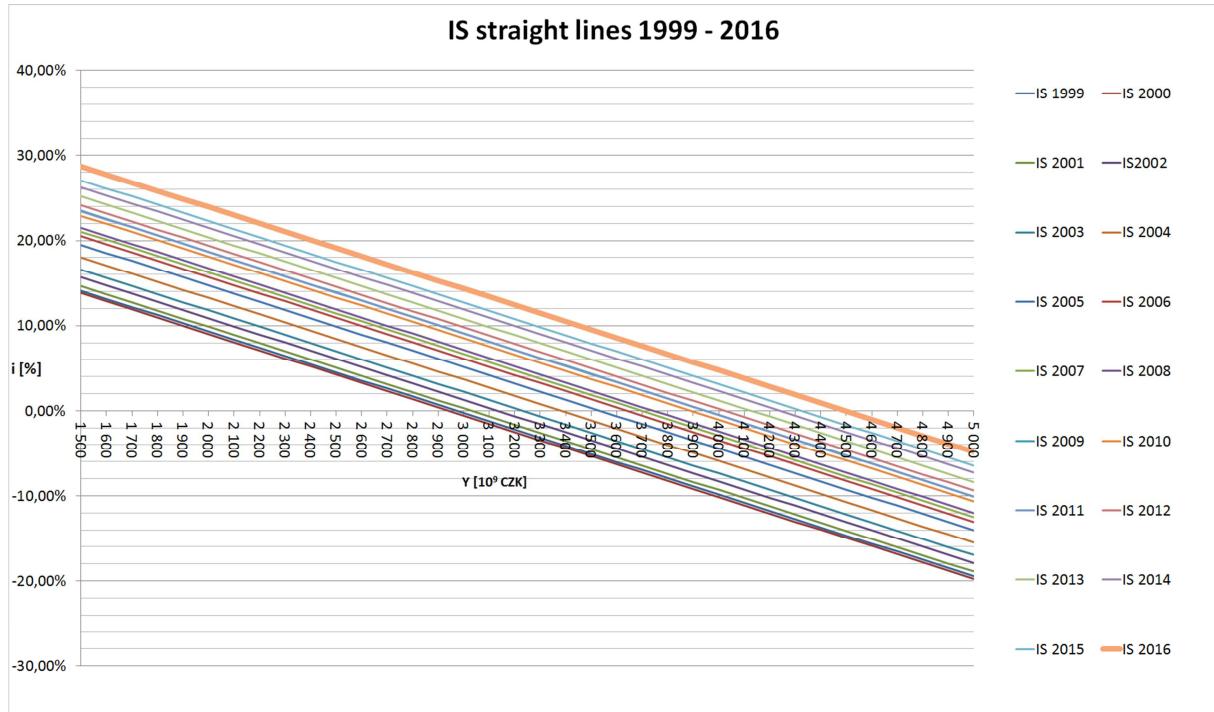


Chart 2 (author)

The same slope of the IS straight lines in the years surveyed stems from the fact that we, for the calculation of their parameters, used long term data for the years 1999 – 2013 and from the fact that the marginal propensity to household consumption (c) for individual years changes only relatively insignificant - see Table 4. With the increasing GDP (Y) the point of intersection of IS straight lines with y -axis increases (IS straight lines shifted to the right).

For the equation (10) describing dependence Y , i and M , is derived for the input data (Table 1) the following parameters:

$$M = 0,507 Y - 16\,274 i \quad [10^9 \text{ CZK}] \quad (15)$$

The symbols' meaning - see equations (10)

The relation between M and i is characterized by a correlation coefficient equal to - 0,769 and the relation between M and Y is characterized by a correlation coefficient equal to 0,963.

Based on the statistical data for the years 1999 - 2013, we derived the following parameters for the LM straight line:

Item	Symbol	Value	Dimension
GDP sensitivity of demand for real money	k	0,507	[\cdot]
Interest rate sensitivity of demand for real money	h	16 274	$[10^9 \text{ CZK}]$

Table 3 (author)

Then the equation for the LM straight line (11) will be in the form:

$$i = \frac{0,507}{16\,274} Y - \frac{M}{16\,274} \quad [-] \quad (16)$$

The symbols' meaning - see equations (8) and (9)

In the years 1999-2016, Graphical representation of LM straight lines for the changing exogenous variable M and for parameters according to Table 3 is as follows:

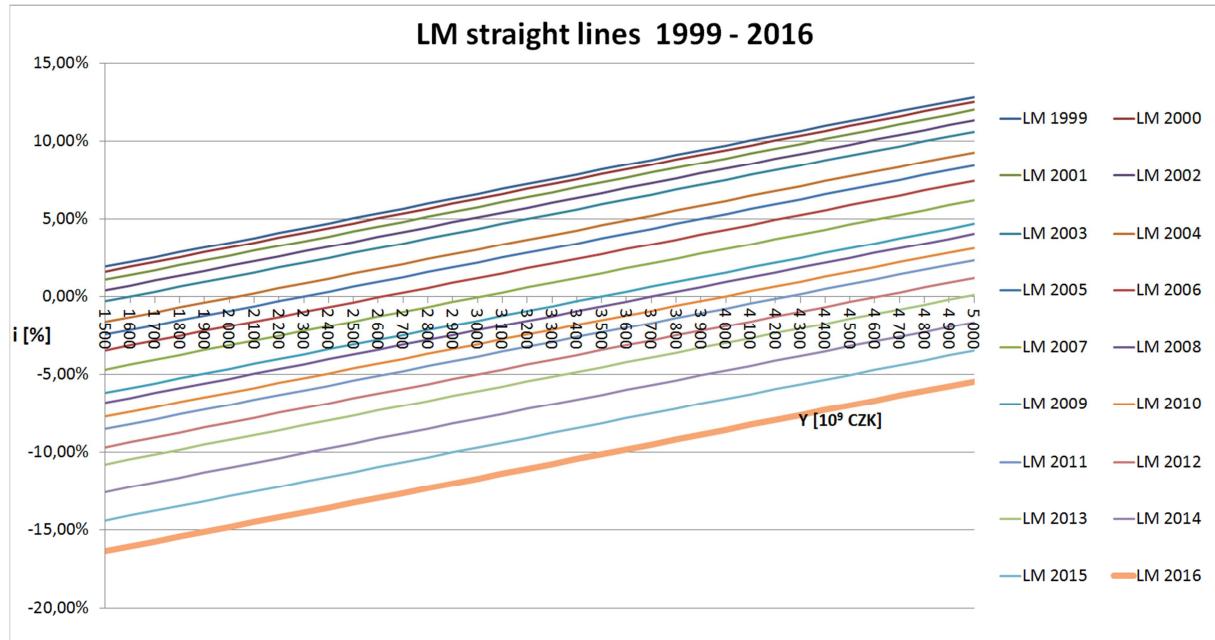


Chart 3 (author)

With the increasing volume of money M1, we can see strong pressure on the decreasing interest rates till the negative values. It is clear from Chart 3 how the CNB's interventions implemented in 2013-2016 have increased the pressure on the declining interest rate - the decrease in the intersection of LM straight lines with the y-axis is much stronger in 2014-2016 than in other years.

Results

For the years 1999-2013, the intersection of the IS and LM lines - the equilibrium state - is calculated depending on variables $G + NGO + NX$ and M from the system of 2 equations:

$$Y = \frac{121+1\ 071+G+NGO+NX}{0.73257854} + \frac{M}{2.06670684} \quad [\text{CU}] \quad (17)$$

$$i = \frac{0.507 Y-M}{16\ 274} \quad [-]$$

The symbols' meaning - see equations (1) and (5)

The course of the actual intersections of the IS and LM straight lines (blue marks) and the course intersections of the IS and LM lines calculated on the basis of our model derived from the system of equations (17) (red marks) is shown in Chart 4.

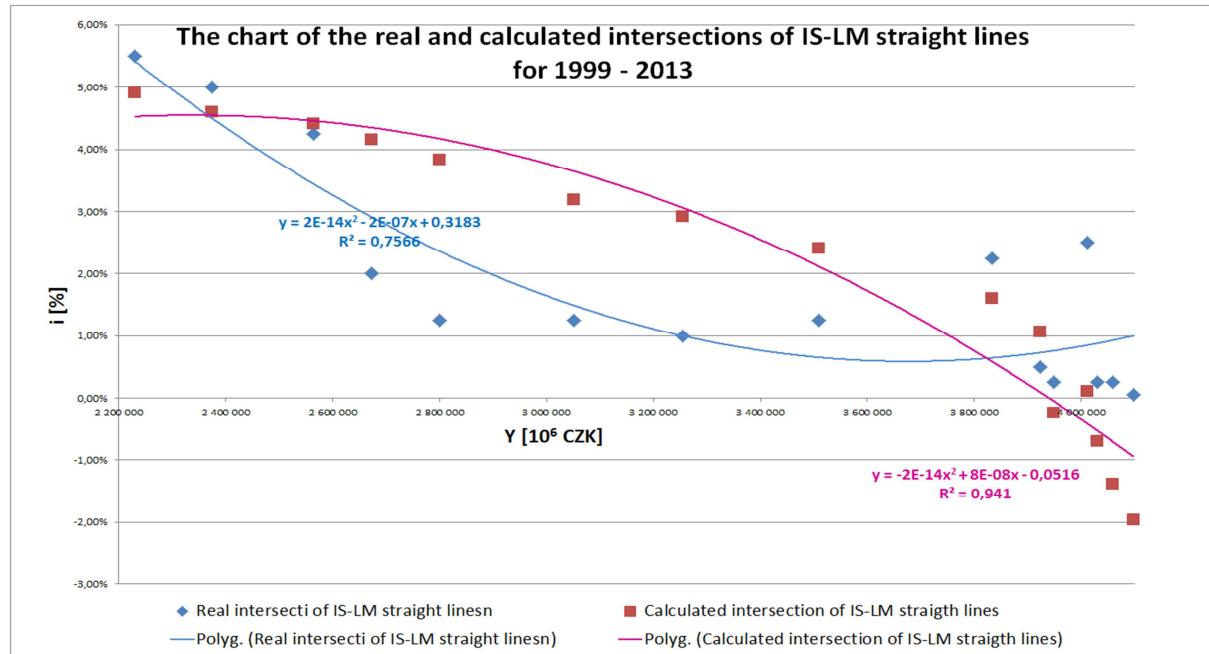


Chart 4 (author)

Chart 4 clearly shows that, with the rising GDP, interest rate in the Czech economy is significantly pushed to negative values. But why did not real interest rates reach negative values?

To reach the intersections of IS and LM straight lines in points which are equal to real equilibrium points for years 1999-2013 (Chart 4), after the analysis, is resulting the following conclusions regarding of parameters IS-LM model:

Item	Symbol	characteristic	Value	Dimension
Autonomous household consumption	\bar{C}	constant	121	[10^9 CZK]
Marginal propensity to household consumption	c	is changing	0.425 - 0.458	[\cdot]
Autonomous investment	\bar{I}	is changing	888 - 1 391	[10^9 CZK]
Interest rate sensitivity of investment	b	constant	5 769	[10^9 CZK]
GDP sensitivity of demand for real money	k	is changing	0.362 – 0.616	[\cdot]
Interest rate sensitivity of demand for real money	h	constant	16 274	[10^9 CZK]

Table 4 (author)

From the detailed analysis for the input data (Table 1), results that in the years 1999-2013, is for Czech economy characteristic that volume of M in the Czech economy decline of 163 [10^9 CZK] per rise of interest (r) on 1 % ($h = 16 274$ [10^9 CZK]), while the GDP sensitivity of demand for real money (k) is for real intersection of IS-LM straight lines moving from 0.36 to 0.62.

An alternative view of the speed of turnover M in Y in the Czech economy ($1/k$) we can see in chart 5.

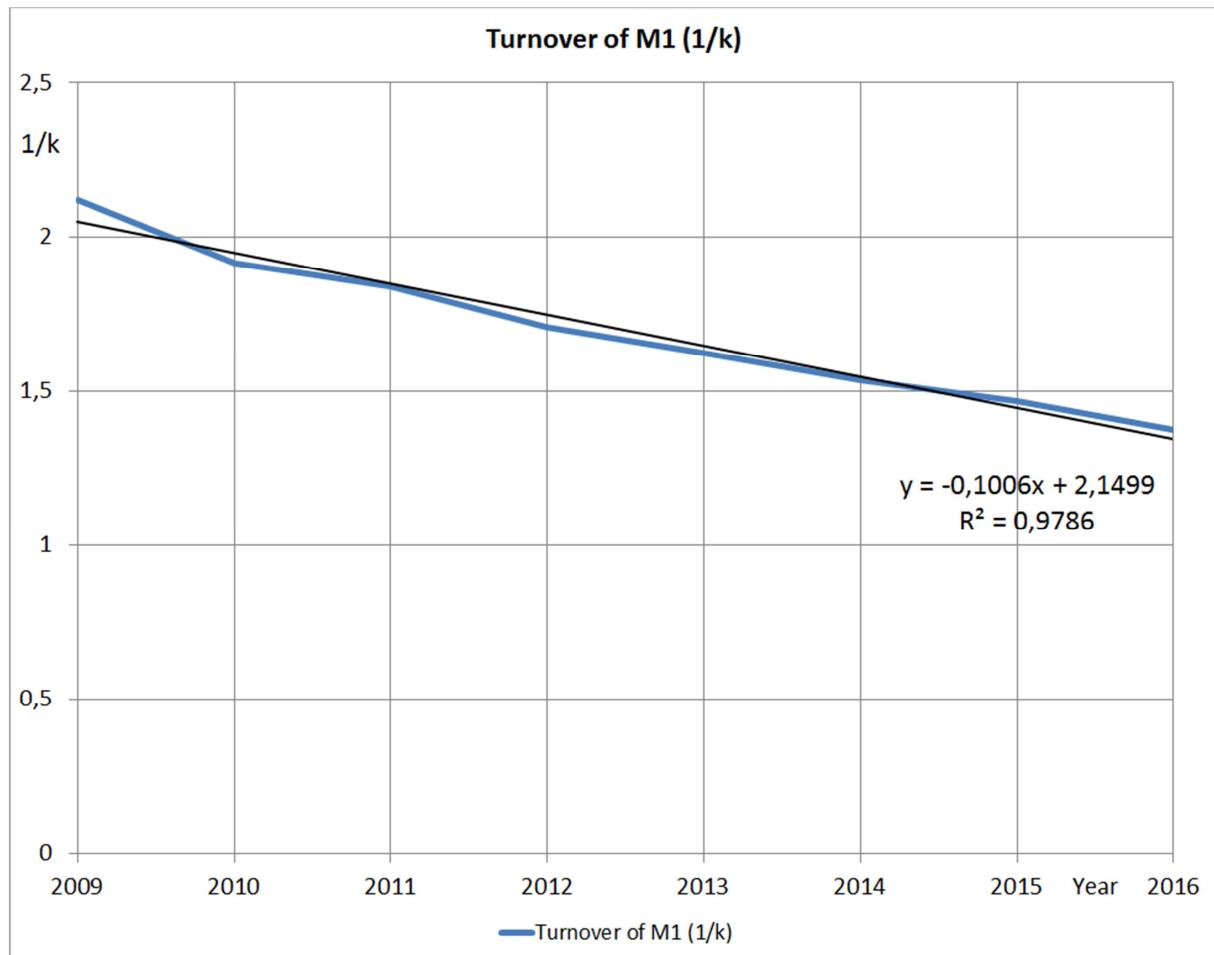


Chart 5 (author)

Given the fact that between 2001 and 2010 in the Czech economy, the share of $M1$ in GDP was around 0.5 i.e. the turnover of $1/k = 2$ (with an average variation of 0.28), then we have to conclude that since 2012 ($1/k = 1.7$), the "dead" non-productive money has begun to appear in the Czech economy. This trend was supported by CNB's interventions for weakening the CZK/EUR exchange rate in the years 2013-2016, when the money turnover ($1/k$) fell to 1.37. It can be estimated that about 1,000 [10^9 CZK] produced by CNB's interventions to depreciate the CZK/EUR exchange rate was unproductively located in the accounts (of speculators).

The real amount of money in the Czech economy ($M1$) - blue line – and the optimal amount of money in the Czech economy calculated on the basis of the derived IS-LM model - red line - is shown in chart 6. In this chart, we can see a widening gap between optimal and real money amount since 2010.

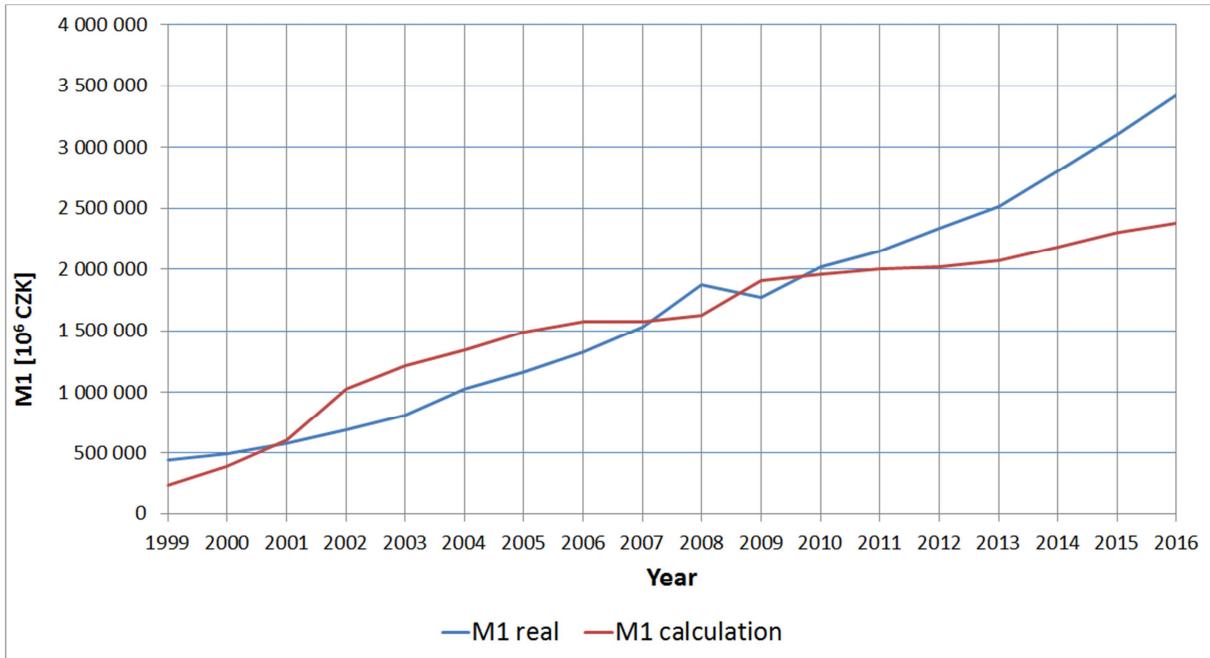


Chart 6 (author)

From the above analysis, it shows that from 2012 there was a surplus of money in the Czech economy, and the growth of the M1 aggregate caused by the CNB's interventions was completely unnecessary and counterproductive in terms of economic development.

Export and import development

In a depth analysis of the impact of CNB's interventions on the Czech economy, it is also important to analyze the development of exports and imports.

For the calculation of export, import and foreign trade balance, is assumed that the volume of foreign trade is largely dependent on the output of the whole economy (GDP). Therefore 2000-2013's export and import data were recalculated to the output of the Czech economy in 1999.

Dependence of export volume on the CZK/EUR exchange rate for input data from Table 1 can be expressed by the equation:

$$NX^{ex} = 3\,154 - 60x \quad [10^9 \text{ CZK}] \quad (18)$$

The symbols' meaning:

NX^{ex} – export for exchange rate x [10⁹ CZK]

x – exchange rate CZK/EUR [CZK]

Let us note the anomaly that from the long term point of view with depreciation of the exchange rate CZK/EUR decrease the Czech economy's exports ($nx^{ex} = -60$). See chart 7.

Dependence of import volume on the CZK/EUR exchange rate for input data from Table 1 can be expressed by the equation:

$$NX^{im} = 2\,717 - 47x \quad [10^9 \text{ CZK}] \quad (19)$$

The symbols' meaning:

NX^{im} – import for exchange rate x [10⁹ CZK]

x – exchange rate CZK/EUR [CZK]

Through combine the equations (18) and (19) the balance of the Czech economy's foreign trade can be expressed by the equation:

$$NX = NX^{ex} - NX^{im} = 438 - 13x \quad [10^9 \text{ CZK}] \quad (20)$$

The symbols' meaning:

NX – the balance of foreign trade for exchange rate x [10⁹ CZK]

x – exchange rate CZK/EUR [CZK]

In the equation (20) is demonstrates that in the Czech economy the balance of foreign trade with depreciating CZK exchange rate is decreasing. This fact can be rationally explained partly by using long term input data and partly by the strong dependence of Czech exports on imported inputs.

Export dependency on the exchange rate CZK/EUR can be expressed by a correlation coefficient equal to -0.927, while import dependency to the exchange rate can be expressed by a correlation coefficient equal to -0.931. Finally the foreign trade balance is correlating with an exchange rate CZK/EUR at -0.847. From the correlation coefficients mentioned above, it could be derived the long-term trend for the Czech Republic's foreign trade development that is, that balance of the Czech Republic's foreign trade is growing with strengthening CZK against the EUR - see Chart 7 and 8. The maximum of foreign trade balance was reached at an exchange rate of ate 27.00 CZK/EUR.

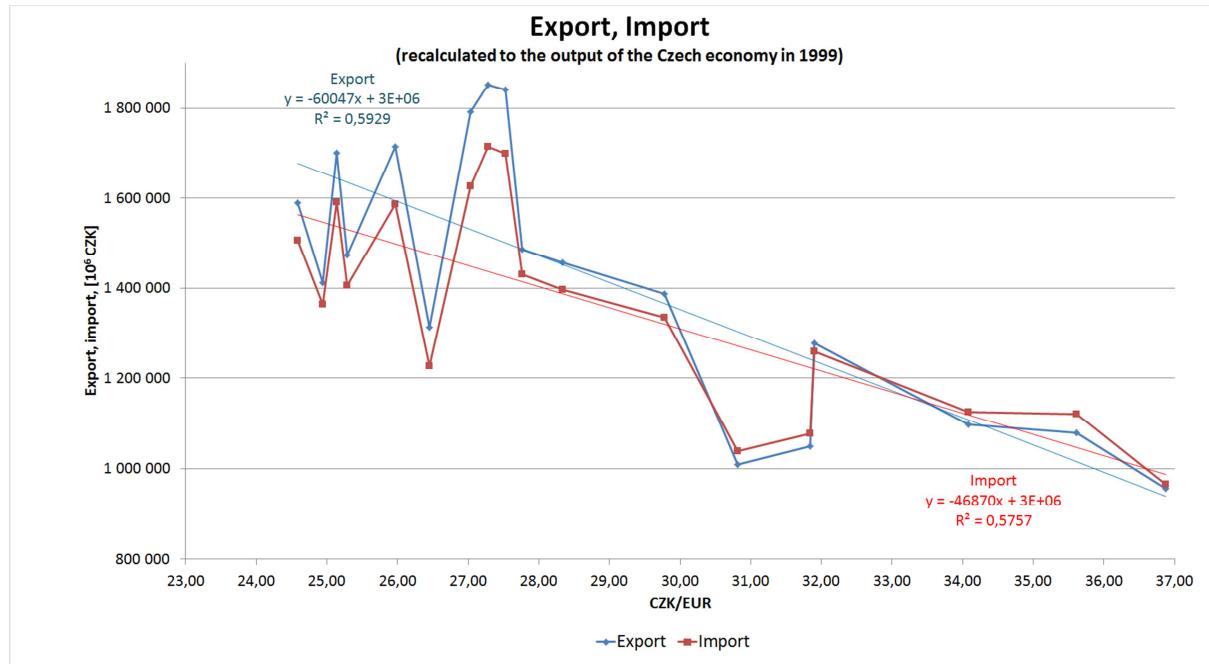


Chart 7 (author)

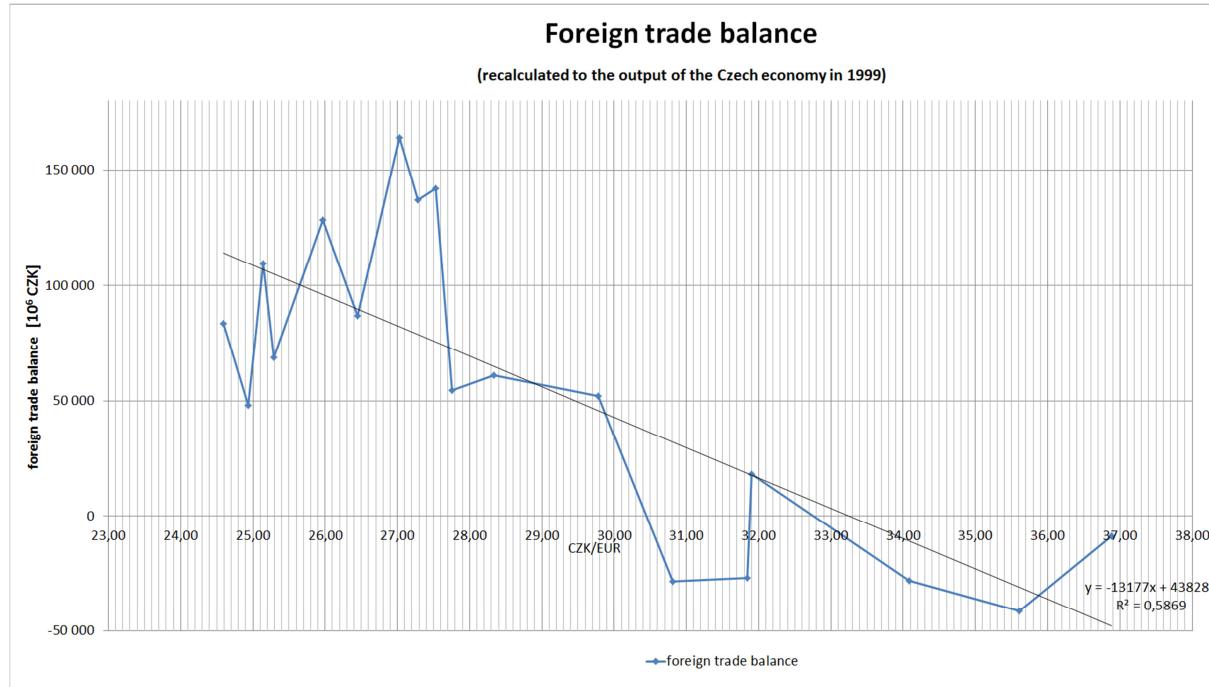


Chart 8 (author)

The result that the Czech Republic's export is stronger in case the stronger CZK, is supported by the preliminary results for first half of 2017 when, after the end of the CNB's interventions and the subsequent strengthening of the CZK, it is possible to estimate that the export of Czech Republic at the end of 2017 exceed the border 4,000 [10⁹ CZK]. However, the greater importance will have the final value of foreign trade balance for the year 2017.

Analysis of year-to-year GDP growth

In regards to the statistical data for the Czech economy's development in the years 1995-2016, we have analysed GDP year-to-year changes (nominal values [10^6 CZK]):

Year	Change in GDP	Inflation	ΔY GDP	ΔC households	ΔG government	Δ NGO non-profit	ΔI investment	ΔNX f. t. balance
	%	%	[10^6 CZK]	[10^6 CZK]	[10^6 CZK]	[10^6 CZK]	[10^6 CZK]	[10^6 CZK]
1995								
1996	14.71%	8.81%	232 162	122 315	35 254	2 280	111 500	-39 187
1997	7.73%	8.63%	139 909	105 210	41 177	1 585	-15 167	7 104
1998	9.71%	10.70%	189 355	77 651	17 318	798	18 157	75 431
1999	4.25%	2.20%	91 018	56 591	37 353	-538	873	-3 261
2000	6.42%	3.72%	143 212	60 806	17 243	1 008	99 427	-35 272
2001	7.99%	4.70%	189 790	78 926	37 606	-1 250	62 660	11 848
2002	4.27%	1.85%	109 614	54 603	60 074	869	-4 093	-1 839
2003	4.73%	0.13%	126 449	64 996	51 900	198	8 898	457
2004	9.00%	2.72%	251 890	89 673	22 468	2 690	78 397	58 662
2005	6.63%	1.89%	202 314	63 822	30 382	3 260	53 641	51 209
2006	7.84%	2.60%	255 195	88 183	35 199	2 664	109 128	20 021
2007	9.24%	2.77%	324 275	118 165	31 920	1 261	175 098	-2 169
2008	4.62%	6.33%	176 957	135 725	33 875	622	14 405	-7 670
2009	-2.18%	1.10%	-87 283	5 690	46 197	714	-206 173	66 289
2010	0.66%	1.42%	25 825	27 163	-2 036	96	31 721	-31 119
2011	2.03%	1.94%	80 353	32 157	3 487	-376	16 017	29 068
2012	0.73%	3.27%	29 278	19 325	-9 083	582	-30 558	49 012
2013	0.94%	1.43%	38 051	26 282	21 926	1 038	-47 478	36 283
2014	5.26%	0.40%	215 534	47 697	23 151	994	105 318	38 374
2015	5.66%	0.30%	244 205	66 117	40 517	798	131 197	5 576
2016	3.43%	0.70%	156 130	73 316	25 759	952	-10 807	66 910

Table 5 (CZSO, author)

Legend of marking:

The GDP growth is lower than inflation (crisis periods) - highlighted in yellow

The major contribution to the GDP growth at the given year - highlighted in green

The highest year-to-year increase of the given item in the period 1996 - 2016 - shown in red

Years influenced by CNB's interventions for depreciation of CZK against EUR - highlighted in blue

From Table 5, we can deduce that in 21 observed years (1996-2016) year-to-year growth of the GDP was mostly driven by **household consumption** - at 11 years; **government consumption** was pulling the GDP growth just in the year 2002 when its year-to-year increase was the highest out of all the observed years. The **increase in investment** contributed mostly to year-to-year GDP growth at 6 periods, the most interesting years are 2014 and 2015, influenced by the CNB's interventions. Increase of the **foreign trade balance** dominated the GDP growth in years 2009, 2012 and 2013, just before the CNB's interventions. Only after two years of high investment activities, the increase in the foreign trade balance in 2016 rose to its second highest maximum in history. In addition to the increase in the foreign trade balance, household consumption was dominated the GDP growth in 2016.

Also it is noteworthy to mention that 2009's GDP developments were the only time when GDP grows expressed in nominal terms fell in to negative value. While at the same time, the foreign trade balance reached the second highest value from previous years, but the decline in investments reached the lowest value in its history.

Household consumption between 1999 and 2016 ranges a relatively narrow interval from 45.65% to 50.68% of GDP (Y). The lowest share of GDP had household consumption in 2006 and 2008 and then in 2014 and 2016, i.e. in the years of the CNB's interventions. During the crisis years 2010 - 2013, the

share of household consumption to GDP was above average and exceeded 48.3% of the GDP; this fact shows that the low household consumption was not responsible for the Czech economic crisis but rather low investment.

A detailed analysis (Table 4) of the results of the IS-LM model showed that in the observed years the investors had a stable tendency to reduce their investment volumes depending on value r , in the amount $58 [10^9 \text{ CZK}]$ per 1 % of interest. In the observed years, depending on the non-economic impacts and altered investor expectations for the future the value of autonomous investment (\bar{I}) is changing. Autonomous investment was the lowest in 1999 and 2002-2004 when it does not exceed 10^9 CZK . It is noteworthy that the highest value of autonomous investment was in 2007 and 2008 at the beginning of the economic crisis when it exceeded the amount of $1.36 [10^9 \text{ CZK}]$ at interest rate of 2.25 % and 2.50 %. In the pre-crisis period investors' expectations for the future were at their highest. The expectations in 2015 and 2016 did not exceed this level, when autonomous investment was lower than $1.25 [10^9 \text{ CZK}]$ at interest rates of 0.05%. The fall in investment caused the GDP decline in 2009 and was the reason for the low GDP growth in 2012 and 2013.

Overall we can state that the CNB's interventions to weaken the CZK/EUR exchange rate did not raise foreign trade balance significantly, but the GDP growth was "dragged" by an above-average increase in investment in 2014 and 2015. The administrative depreciation of the CZK against the EUR brought ca 8 % lower investment and wage costs in the Czech Republic for both euro and dollar investors. It would be worth to do a more in depth analysis if these investments were focused on assembly plants in the automotive and other production fields, or whether these investments brought to the Czech Republic scientific and research activities and production based on innovation or on technical and information development.

Conclusions

The course of straight lines functions of the IS-LM model in the years 2012-2016 are shown in Chart 9:

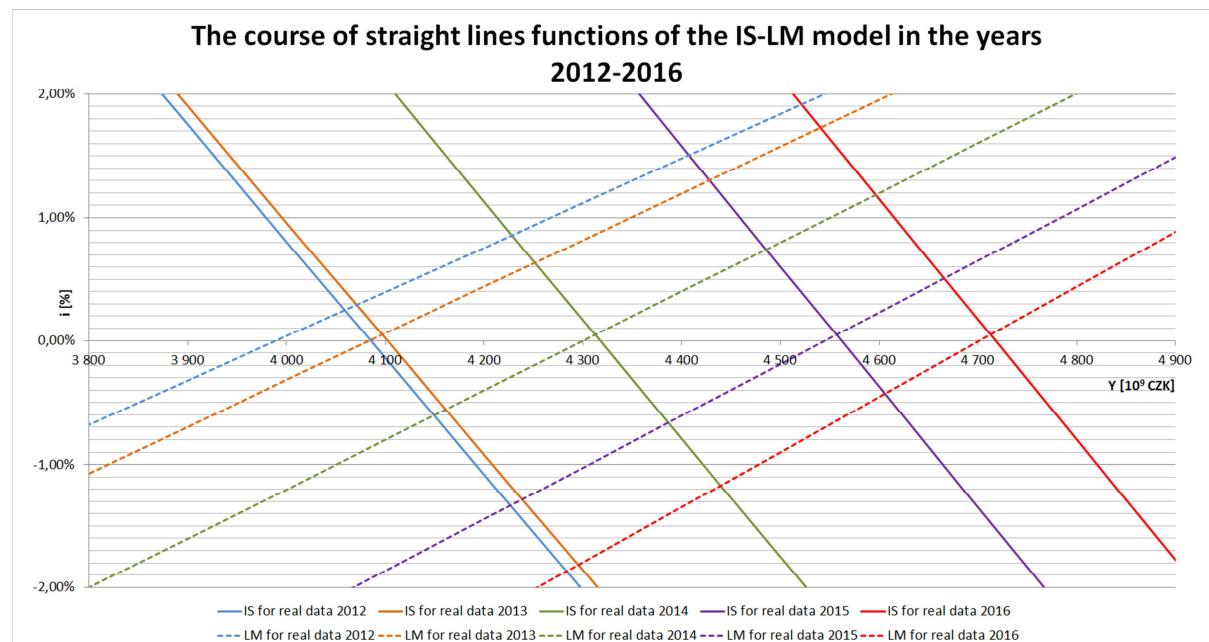


Chart 9 (author)

Reach an intersection of the straight lines function of the IS-LM model for the years 2012-2016 in the actual points Y and i , the parameters of general IS-LM model given by equations (14) and (16) must be adjusted as follows:

Item	s y m b o l	Value for general model	Model parameters for real data 2012	Model parameters for real data 2013	Model parameters for real data 2014	Model parameters for real data 2015	Model parameters for real data 2016	Dimen- sion
Autonomous household consumption	\bar{C}	121	121	121	121	121	121	[10^9 CZK]
Marginal propensity to household consumption	c	0.447	0.456	0.458	0.446	0.437	0.438	[-]
Autonomous investment	\bar{I}	1 071	1 072	1 013	1 118	1 250	1 239	[10^9 CZK]
Interest rate sensitivity of investment	b	5 769	5 769	5 769	5 769	5 769	5 769	[10^9 CZK]
GDP sensitivity of demand for real money	k	0.507	0.586	0.616	0.652	0.682	0.728	[-]
Interest rate sensitivity of demand for real money	h	16 274	16 274	16 274	16 274	16 274	16 274	[10^9 CZK]

Table 6 (author)

Legend of marking:

Changed parameters - shown in red

We had to make the biggest changes for parameter k , when it rose to 0.728 (by 44%), i.e. the money turnover $1/k$ dropped to 1.37.

To achieve a real GDP value of 4,713 [10^9 CZK] in 2016 by an interest value of, for example, 2.5 %, we would have to achieve the following values for parameters of IS-LM model:

Item	Symbol	Model parameters for real data 2016	Model parameters for interest = 2,5 % 2016	Dimension
Autonomous household consumption	\bar{C}	121	121	[10^9 CZK]
Marginal propensity to household consumption	c	0.438	0.438	[-]
Autonomous investment	\bar{I}	1 239	1 380	[10^9 CZK]
Interest rate sensitivity of investment	b	5 769	5 769	[10^9 CZK]
Supply for real money	M	3 423	2 423	[10^9 CZK]
GDP sensitivity of demand for real money	k	0.728	0.600	[-]
Interest rate sensitivity of demand for real money	h	16 274	16 274	[10^9 CZK]

Table 6 (author)

Legend of marking:

Changed parameters - shown in red

In order to achieve an interest rate of 2.5% in the real economy of 2016, must for example autonomous investment (\bar{I}) grow by 11% to 1 380 [10^9 CZK]. Supply for real money (M) would have to decrease by 1 000 [10^9 CZK] to 2 423 [10^9 CZK] and GDP sensitivity of demand for real money (k) would have to fall to 0.6 - the money turnover rises to 1.7.

The CNB can actively influence the amount of money M1. The government can influence the positive climate for investment growth through its policy.

The IS and LM straight lines chart would then, under the new hypothetical parameters of the IS-LM model according to data in Table 6 looked as follows (dashed lines):

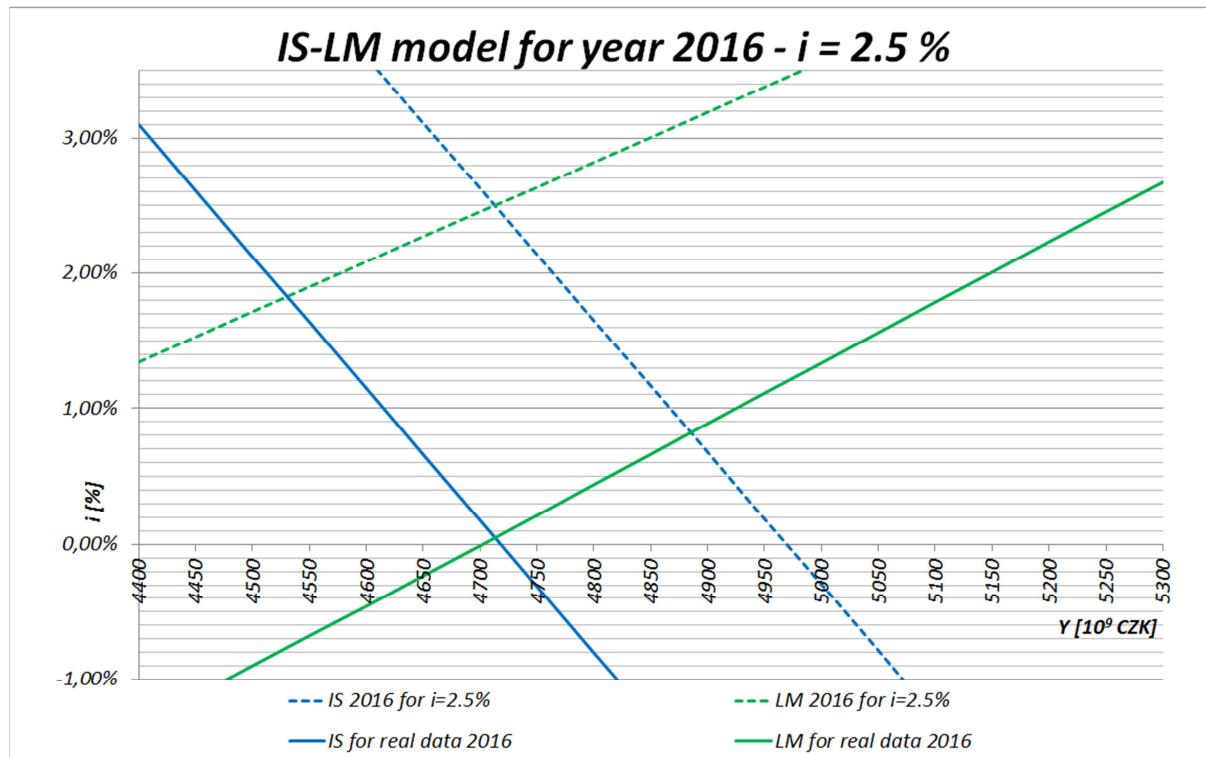


Chart 10 (author)

The author of the article is aware of the complexity of the economic models and does not claim to achieve the exact information ability of such simplified IS-LM models. The aim was to indicate that the IS-LM model can be displayed in the charts with x and y axis marked by real values and that such a model is possible to use for demonstrating changes which can be reached by altered economic parameters.

At the same time, I wish to point out that the attempt to influence the development of the national economy in a desired direction by an administrative influencing of some parameters (for example the CZK/EUR exchange rate) is from the wider economic context considerably problematic and can have unpredictable results in reality. In the economy systems, it is not always determined which variable is dependent on another variable, and these dependencies can change over time and space. The question is whether the level of inflation depends on the GDP growth or GDP growth on level of inflation. On the basis of the above accomplished analysis, the author of this article considers the efforts to boost GDP growth through inflation raise, which was achieved by weakening the CZK/EUR exchange rate as problematic and inefficient at least.

What conclusions are possible to be made on basis of IS-LM model for the Czech economic results in 2013 - 2016?

- The reason for the Czech economic crisis from 2008 to 2013 was not low household consumption, but the low consumption of the government (2010, 2011, 2012), low investment (2009, 2012, 2013) and low foreign trade balance (2008, 2010).
- The reason for CNB's interventions to depreciation the CZK/EUR exchange rate could not be the low growth of foreign trade balance. In years 2012 and 2013 was growth of foreign trade balance crucial to GDP growth.
- Due to the generation of about 1,200 $[10^9 \text{ CZK}]$ under the CNB's interventions for the depreciation of the CZK/EUR exchange rate, there was pressure to lower interest rates theoretically to negative values, and unproductive "dead" money was lying unnecessarily in accounts.

- d) The CNB's intervention did not lead to a strengthening of the growth in the foreign trade balance. On the contrary, from the model follows the fact that the higher foreign trade balance in the Czech Republic is reached by a stronger CZK.
- e) The CNB's interventions did not lead to an increase in household consumption.
- f) The increased activity of investors led to the recovery of the Czech economy in 2014 and 2015. The growth of the foreign trade balance and the household's consumption arrived directly in 2016 after two years of above average investment growth.
- g) CNB's interventions did not have a direct effect on the inflation growth in the Czech economy. The author of the article believes that CNB's intervention impeded an increase of inflation.

The question for more in depth economic analysis is whether inflation may rise at extremely low interest rates and pressure to further reduce them. Extreme low interest rates leads to a depreciation of the real value of savings and it can be assumed that the market economy subjects try to defend against this. On the one hand, it could be assumed that under these circumstances economic subjects will not save money, but spend it - this should exert pressure on price increases. On the other hand, as part of the combination of mistrust in future economic developments and the desire to have a reserve for worse times, it is to be expected that economic subjects will invest free money in various commodities and investment products (gold, real estate, ...) instead of "irresponsibly" spending money on consumption. This is confirmed by statistical data and calculations where the share of consumption in GDP changes only within a limited interval.

At this time, I would like to express my opinion about the state's role and its institutions in the regulation of the economy. Economic systems are naturally unstable and tend to oscillate in an undesirable way, which leads to cyclical crises. To eliminate such oscillation, feedback must be implemented. However, if this feedback is weak or incorrect, the system tends to continue to be oscillated. If this feedback is too strong or incorrect, the whole system is undesirably muted. It is a question of whether the state in its present form is able to optimize its regulatory intervention in the economy from this somewhat technocratic view on the oscillation of the performance of economic systems, and if it is not better to allow certain oscillations of economic systems (occurrence of short-term crises) rather than moderate the economic systems by irresponsible regulatory measures. The Czech Republic has with irresponsible regulatory measures rich experience from the years 1948 - 1989 and in the modern development of 1997 and 1998.

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