

GLOBALISATION UNDER DYNAMIC ECONOMIC MODELS

1. General approach;
2. Global Economic Model 2004;
3. Global Economic Model 2007;
4. Global Economic Model 2008;
5. Conclusions.

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**Abstract**

*The paper deals with the necessity to find a better way to forecast the evolution of the global economic environment under the present crisis. As a result, the paper realises a comparative analysis of the latest GEM models.*

*According to other dynamic, stochastic and general equilibrium models, GEM models combine the long term characteristics of the business cycles models with the short term Keynesian models.*

**Keywords:** *international conjuncture, business cycle approach, macroeconomic connections, regional blocks.*

**JEL Classification:** C54, C59.

**1.** According to the globalisation growth process, the decision factors, the international organisations, the multinational companies and the individual specialists asked for the necessity to create global dynamic

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models able to quantify and forecast the world socio-economic evolution.

The global models evolved as quality and number of quantified restrictions. Moreover, the global models' restrictions have to quantify the international conjuncture, in order to be able to express the economic evolution under the present crisis, for example.

The global economic models (GEM) can be analysed in terms of quality using at least three steps.

The first of them is GEM 2004.<sup>1</sup> This model gave a nontechnical approach of the development, using microeconomic connections which were developed inside the Research Department of IMF. Gem 2004 has a predecessor in MULTIMOD model, which was focused on the analysis of the connections between the world countries.

GEM 2004 was based on the connection between the academic research and the existing economic models (see figure 1).

According to figure 1, the academic research develops a new theoretic impulse with powerful connections with the economic models, as a response to the political challenges and to the limits of the existing mathematical models.

When the new models are able to process the existing data, they become bases for the existing political models development, starting from one country version and continuing with multistate models.

The academic and political communities filter the new specific ideas, and their paradigms become dominant.

At a moment, new phenomenons from the real economy operate and are implemented new dominant paradigms.

The evolution of the macroeconomic models can be structured on the following steps:

- the Keynesian adaptive expectations approach (adaptive expectations): this approach allows the researchers to evaluate the economic policies impact and cyclical shocks under a unified manner. The main lacuna of this approach is that it allows politicians to misguide public opinion, creating a bias connected to

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<sup>1</sup> **Bayoumi Tamim and al.**, *GEM- A New International Macroeconomic Model*, International Monetary Fund, Washington DC, 2004.

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the expansionist macroeconomic policies. This approach was covered by Flemming<sup>1</sup> and Mundell<sup>2</sup> growth models;

- the Keynesian rational expectations approach (rational expectations): allows the generation of a more realistic answer to the economic cyclical dysfunctions. On the other hand, this approach is not too powerful theoretically based, and create difficulties connected to the analysis of economic policies effects on the aggregate supply. The most significant model from this category is MULTIMOD;<sup>3</sup>
- real business cycle approach: has a powerful theoretical base which improves the supply approach and allows the direct quantification of the economic welfare. The price flexibility premise confines the analysis area of the macroeconomic policies. Such a model is that of Mendoza;<sup>4</sup>
- general stochastic dynamic equilibrium approach: integrates the aggregate supply and demand answers using the microeconomic theory. These models are new and present difficulties connected to their building and implementation. GEM models are representative for this category.

2. Global Economic Model 2004 (GEM) operates with firms which produce goods, households which consume and supply labour and capital to the enterprises and a governmental sector, which collects taxes and realise specific expenditures.

The microeconomic structure of GEM 2004 uses standard functional approaches, which allow enterprises and consumers to be aggregated as a single entity.

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<sup>1</sup> **Fleming, J. Marcus**, *Domestic Financial Policies under Fixed and under Floating Exchange Rates*, Staff Papers, International Monetary Fund, Washington, November 1962, pp. 369-379.

<sup>2</sup> **Mundell, Robert A.**, *Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates*, Canadian Journal of Economics and Political Science 29, November 1963, pp. 475-485.

<sup>3</sup> **IMF**, *MULTIMOD Mark III, The Core Dynamic and Steady-State Models*, IMF Occasional Paper No. 164, 1998.

<sup>4</sup> **Mendoza Enrique G.**, *Endogenous sudden stops in a business cycle model with collateral constraints: a Fisherian deflation of Tobin's Q*, NBER Working Paper Series, Working Paper 12564, 2006.

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In terms of output, the small enterprises, which produce different goods, operate under the same substitution elasticity. As a result, GEM 2004 uses simple CES production functions, which quantify labour and capital.

The goods are differentiated and the enterprises have the power on the market and are able to restrict the output, in order to obtain supplementary profits.

The intermediary goods and the capital are produced and can be sold, and the labour from every country is assumed to be fixed. It is the labour element that makes the choice for the rates of work, entertainment or rest.

Labour obtains revenues and buys domestic or foreign goods. This process is described using a CES function.

The model is focused on trade and macroeconomic connections. As a result, its fiscal and financial components are almost simple.

The limit of the forecast is 25 years, divided into 100 quarters. GEM 2004 started on the idea that the competition will grow across the EU and USA. This process has to bring benefits for the world economy, especially for the EU (see table 1).

Using the information from table 1, they can point out some specific trends during 2004-2029. The Euro area real GDP will grow by 12.4%, as a result of the capital stock (+20%) and working hours (8%) growth. Almost 2/3 of these benefits come from goods market reformation and more than 1/3 from labour market reformation. The GDP forecast evolution is presented in figure 2.

The consumption growth represents 2/3 of the real GDP growth in the Euro area and reflects the investment growth and the Euro depreciation (see figure 3).

The growth of the consumers' revenues in the Euro area will support the growth of the imports from the rest of the world. The foreign consumption will grow by 1.25%, which represents 1/6 of the same indicator growth in the Euro area.

The economic welfare will growth by 2.5% in the Euro area and 1.25% in the rest of the world, according to the consumption.

On the other hand, the revenues and the prices become more flexible and support the Central European Bank's monetary intervention, in order to achieve a cyclical stabilisation of the economy.

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The growth of the national output doesn't vary, even if the control parameters change (excepting the labour market changes, which depend on the connection between the number of working hours and the real wage evolution).

The effects associated with the control parameters are lower in the rest of the world, especially when the analysis is focused on the domestic goods substitution for those from import.

The economic reforms are able to support the fast growth of investment, but the consumers' benefits will come latter (see figure 4).

3. Global Economic Model 2007 was implemented by the National Bank of Canada specialists. They extended the standard GEM model by adding under analysis the traded and unsold goods sectors, which cover petroleum products and non-oil products.<sup>1</sup>

Moreover, the petroleum sector was decomposed in petroleum products for production and petroleum products for consumer retail.

GEM 2007 is a multiregional model which covers the global economy and which allows the analysis of the bilateral trade fluxes and relative prices (including the exchange rates) for every region.

The model divides the world economy into five regional blocks: Canada (CA), USA (US), Asian emergent economies (AS), goods exporter countries (CX) and the rest of the world countries (RC), as in table 2.

Every one of these five regional blocks is composed of:

- enterprises sector (monopolistic type), which produces rare materials, intermediate and final goods;
- two categories of households (in order to delineate their limited liquidity holdings by the consumers' comings), which consume final goods and which represent the labour supply for the enterprises;
- government, which consists of a fiscal authority (which consumes goods and services financed from taxes and loans) and a monetary authority (which influences the short term interest rates, using monetary policy).

Under GEM 2007, the enterprises cover the goods supply for

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<sup>1</sup> Lalonde René, Muir Dirk, *The Bank of Canada's Version of the Global Economy Model (BoC-GEM)*, Ottawa, 2007.

domestic and foreign consumers and their necessary labour from the analysed country. The enterprises need intermediate goods, which can be bought from domestic and foreign producers.

On the other hand, the consumers shape their demand for the domestic and foreign enterprises goods and ensure the labour for the national enterprises.

Under its nonlinear form, GEM 2007 can be used as a system characterised by demand, supply and prices functions which uses the CES constant substitution elasticity.

The practical use of GEM 2007 is based on the following premises:

- in the regions where the rest of the world impact is present, the regional indexes are explicitly incorporated into notations, where H represents the domestic region and R the representative region for the rest of the world;
- the productivity trend (TREND) is the same for the world economy. Its annual growth rate during the time period  $t \rightarrow \tau$  is  $g_t, \tau$ . All quantitative variables from the model are expressed in terms of TREND. But the productivity growth represents only a component of the economic growth. Another component is the population growth, but the model assumed that this growth is zero during the forecast period. Moreover, all prices are considered as relative;
- the variables which are not explicitly indexed are expressed as average terms on capital;
- the forecast periods are the quarters, and the variables have annual values.

GEM 2007 is implemented on the following modules:

*Enterprise:*

In every region, every enterprise is indexed from  $s \in [0, ss]$ , where  $ss$  represents the region size in the world ( $0 < ss < 1$ ).

Enterprise  $s$  produces  $S_t(s)$  during  $t$  period, using capital  $K(s)$ , labour  $L(s)$  and a fixed factor which is not a consistent resource  $LAND(s)$ . These elements are quantified under a CES function:

$$S_t(s)^{\frac{1}{\xi_s}} = Z_{s,t} \left[ \alpha_{LAND_{s,t}}^{\frac{1}{\xi_s}} \left( Z_{LAND_{s,t}} LAND_t(s) \right)^{\frac{1}{\xi_s}} + \left( 1 - \alpha_{K_{s,t}} - \alpha_{LAND_{s,t}} \right)^{\frac{1}{\xi_s}} \left( Z_{L_{s,t}} l_t(s) (1 - \Gamma_{L_{s,t}}) \right)^{\frac{1}{\xi_s}} + \alpha_{K_{s,t}}^{\frac{1}{\xi_s}} \left( Z_{K_{s,t}} K_t(s) (1 - \Gamma_{K_{s,t}}) \right)^{\frac{1}{\xi_s}} \right]$$

where:  $Z_s$  - common shock connected to the productivity of the enterprises which produce goods;

$Z_{LS}, Z_{KS}, Z_{LAND\ s}$  - productivity shocks connected to labour (L), capital (K) and land (LAND);

$\Gamma_{KS}, \Gamma_{LS}$  - costs real change as a result of the capital and labour change.

*Households:*

In every region, the house holds are indexed by the indicator  $j \in [0, ss]$ , the same as that connected to the labour inputs.

Some households can access the capital markets. Those which have no access to the capital markets finance their goods consumption exclusively from their wages.

The utility function for the households is:

$$u(C, l) = U(C) - V(l).$$

But the labour growth rate is not the same with the productivity growth rate. As a result, the households' utility function has to be multiplied as:

$$U(C, l) = U(C) * (-V(l)) \text{ or}$$

$$U(C, l) = U(C - V(zl)),$$

where:  $z$  - productivity level ( $z = \text{TREND}$ ), which is directly included in the utility function.

*Government:*

The government has a double role under GEM 2007. It is a fiscal agent, which collects and distributes the revenues from taxes. Second, it is a monetary authority, which ensures a specific stability for the national economy.

- as fiscal agent: the public expenditures have three destinations: the government consumption ( $G_C$ ), the governmental investment ( $G_I$ ) and the public acquisitions of nontrade intermediary goods ( $G_N$ ).

The governmental consumption can be assumed to represent the goods acquisitions, the governmental investment are focused only on the fixed capital and  $G_N$  quantifies the wages and services expenditures.

GEM 2007 covers seven sources of net revenues from taxes: taxes on the capital revenues ( $\tau_K$ ), taxes on labour revenues ( $\tau_L$ ),

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flat taxes and households net transfers (TT), tariffs on the imports from R region to H region ( $\tau_{TRF}$ ), revenues from the crude oil extraction ( $\tau_{ROYAL}$ ), a tax on the oils value used in goods production ( $\tau_{OIL}$ ) and a tax on the gas value ( $\tau_{GAS}$ ).

The government finances the public expenditures excess (more than the net revenues from taxes) using the claims emission in nominal currency (B) per capita.

The government budgetary contraction is described by the equation:

$$B_t \geq (1 + i_{t-1}) \frac{B_{t-1}}{\pi_{t-1,t} g_{t-1,t}} + G_t - G_{REV,t},$$

where:  $G_t = G_{C,t} + \rho_{E,t} G_{I,t} + \rho_{N,t} G_{n,t}$

- as monetary authority: the government establishes a target for its monetary policy and uses the short term nominal interest rate control as instrument ( $i_t$ ).

GEM 2007 implements the monetary policy according to a forecasted inflation rate. As a result, the nominal interest rate is calculated according to the average lag ( $i_{t-1}$ ) and the neutral current interest rate ( $i_t^{neut}$ ).

The neutral current interest rate represents the interest rate at which the focused variables are stabilised. This means that the real interest rate is a constant which is reported to the economic growth rate and the preferences rate, as in the next equation:

$$(1 + i_t)^4 = (1 + i_{t-1})^{4\varpi_i} (1 + i_t^{neut})^{4(1-\varpi_i)} E_t (\pi_{t-1,t+3}^X - \Pi_{t-1,t+3})^{\omega_1} (GDP_t / GDP_{POT,t})^{\omega_2}$$

GEM 2007 simulation used the key parameters presented in table 3. As a result of the simulation, the economic evolution of the regional blocks was different (see figures 5-8).

The greatest quarter economic growth rates will be achieved by the Asian emergent economies.



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4. The latest GEM model is the Global Economic Model 2008. It was realised in the USA.<sup>1</sup> According to this model the world economy is analysed on the following sectors:

- households: which consume final goods and supply labour (l) to all domestic enterprises. Some households have not access on the capital markets and they finance their consumption only from their work revenues. Other households benefit of the domestic firms portfolio and the domestic capital stock (K) on which they rent to these firms. Moreover, they buy and sell two kinds of securities: domestic (in national currency) and international.

When the households buy and sell international stocks, they pay a bonus (charge) to the financial intermediary, according to the situation of the national total net actives.

The labour and the capital are assumed to be immobile on the international market. The capital market is a competitive one and the capital accumulation is influenced by the costs adjustment.

The wages contracts are relatively rigid on the labour market;

- enterprises: produce final goods and supply intermediary services. There are two kinds of final goods: consumption goods (A) and investment goods (E), which are produced by the enterprises on a perfect market.

The consumption goods are bought by the households or the government ( $G_C$ ). The demand for the investment goods is supported by private agents (I) and public sector ( $G_I$ ).

The final goods are made using all disposable intermediary goods inputs. There is a great diversity of intermediary goods. Every intermediary good is produced by a single enterprise, which operates on a monopolistic market. The intermediary goods are produced using domestic labour and capital. The intermediary goods can be non-tradable (N) and tradable (T) on the international market.

The non-tradable intermediary goods can be bought by the government ( $G_N$ ) or can be used to produce final goods ( $N_N$ ).

The tradable intermediary goods used by the domestic

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<sup>1</sup> **Pesenti Paolo**, *The Global Economy Model (GEM)*, Federal Reserve Bank of New York, NBER and CEPR, 2008.

enterprises are noted as  $Q$ , and the imports as  $M$ ;

- government: buys two types of domestic final goods and non-tradable services. Under treasury, the government finances its expenditures using the net taxes on the domestic private sector. The government is able to manipulate the short term nominal interest rate by the support of the national bank.

The monetary policy is analysed as the government credible commitment to guaranty the prices stability, using the manipulation of the short term nominal interest rate.

The world economy is assumed to be formed of  $N$  regional blocks. The world economy dimension is normalised at 1. The dimension of every country  $H$  is noted as  $s_H$ , where  $0 < s_H < 1$  and  $\sum_H s^H = 1$  for  $H \in N$ .

The world economy trend is the variable TREND. The global gross economic growth rate during  $t$ - $\tau$  time period is  $g_{t,\tau}$ . It is calculated as:

$$g_{t,\tau} = \frac{TREND_\tau}{TREND_t}$$

All the quantitative variables from every country are estimated according to TREND. The only exception is the labour contribution  $l$ , quantified as endowment. On long term,  $g_{t,t+1}$  converges to  $g_{ss}$ , and  $g_{t,\tau}$  converges to  $g_{ss}^{\tau-t}$ , where  $g_{ss}$  is a constant.

The nominal prices in national currency are noted as variables capital, and the relative prices are noted as sensitive variables.

In every country, the relative prices are quantified according to the domestic consumption, using the consumption prices index (CPI). This presumption doesn't affect the generality degree of the model.

During  $t$ - $\tau$ , the inflation rate is noted as  $\pi_{t,\tau}$  and is calculated as:

$$\pi = \frac{P_{A,\tau}}{P_{A,t}}$$

5. GEM models were created using the latest researches from the international finance and monetary economics.

These models are based on the New Open Economy theory,

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implemented by Obstfeld and Rogoff.<sup>1,2,3</sup>

Nowadays, GEM represents an inter-temporary approach which is able to analyse the fundamental problems of the international economic policy and the structural shocks effects, using the connections between different countries and regional blocks.

According to other dynamic, stochastic and general equilibrium models, GEM models combine the long term characteristics of the business cycles models with the short term Keynesian models.

Moreover, GEM models realise a microeconomic construction which allows an integrated analysis of the positive elements and those connected to the economic welfare.

A more useful way to implement GEM models is to familiarise with their characteristics and notes using graphs.

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<sup>1</sup> **Obstfeld M., Rogoff K.**, *Exchange Rate Dynamics Redux*, *Journal of Political Economy* 103, 1995, pp. 624-660.

<sup>2</sup> **Obstfeld M., Rogoff K.**, *New Directions for Stochastic Open Economy Models*, *Journal of International Economics* 50 (1), 2000, pp. 117-153.

<sup>3</sup> **Obstfeld M., Rogoff K.**, *Global Implications of Self-Oriented National Monetary Rules*, *Quarterly Journal of Economics* 117, 2002, pp. 503-36.

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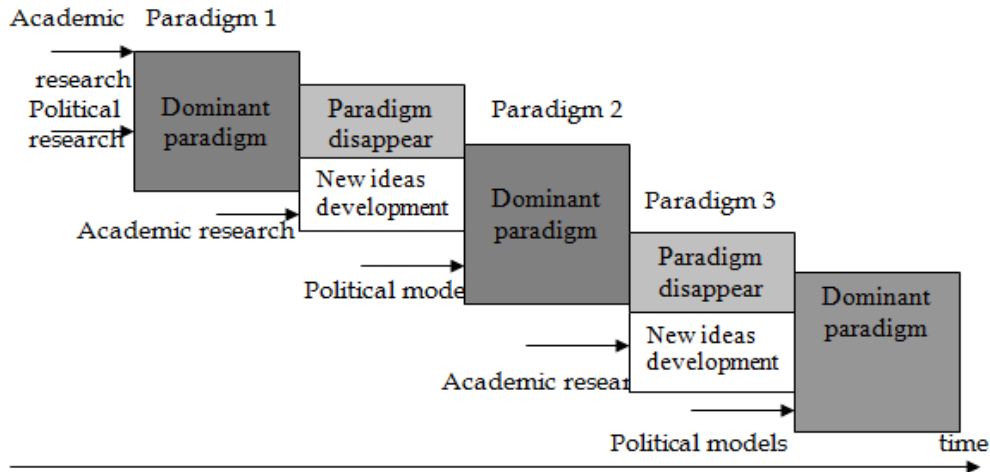


Figure 1: GEM 2004 structure

Source: personal contribution using Bayoumi Tamim (2004), p.3.

Table 1: Economic reforms long term effects forecast under GEM 2004 (percentage deviation from base year)

	Goods market reformation	Labour market reformation	Both cumulated reforms
<i>Euro area</i>			
GDP	8.6	3.5	12.4
Consumption	4.9	3.3	8.3
Investment	17.0	3.5	21.2
Effect on labour	4.5	3.6	8.3
Real exchange rate	4.2	1.1	5.3
Utility	1.9	0.9	2.0
<i>Rest of the world</i>			
GDP	0.7	0.2	0.8
Consumption	1.0	0.3	1.3
Investment	0.5	0.1	0.7
Effect on labour	0.1	0.0	0.2
Real exchange rate	0.9	0.3	1.2

Source: Bayoumi, Laxton and Pesenti (2004).<sup>1</sup>

<sup>1</sup> Bayoumi T., Laxton D. and Pesenti P., *Benefits and Spillovers of Greater Competition in*  
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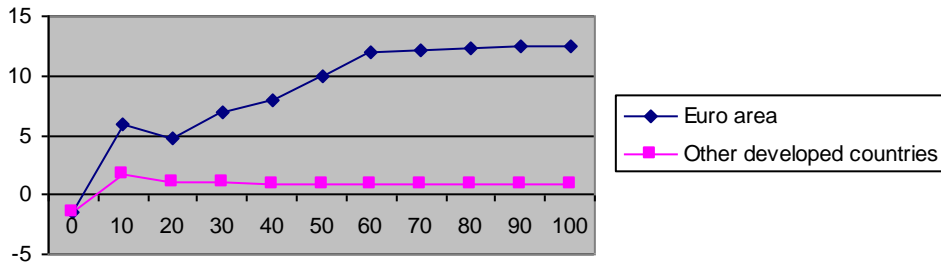


Figure 2: Real GDP quarter evolution (%)

Source: personal contribution

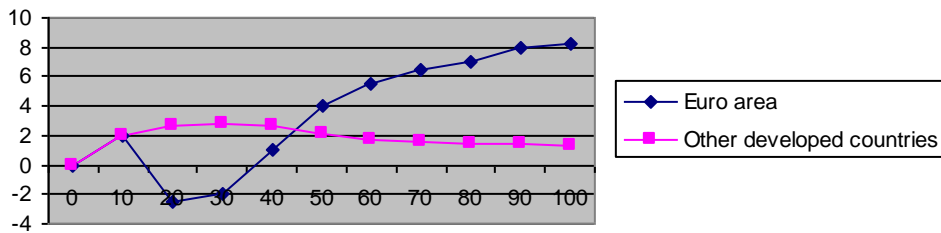


Figure 3: Consumption quarter evolution (%)

Source: personal contribution

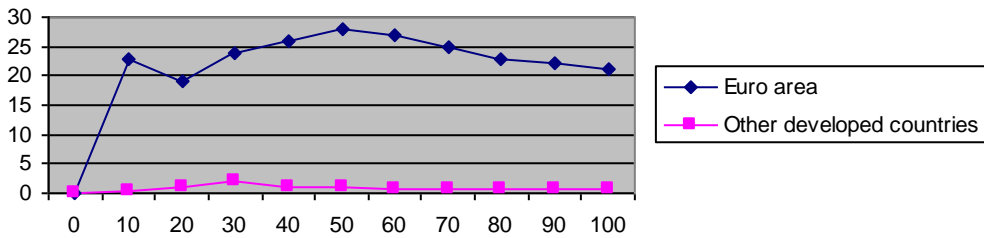


Figure 4: Investment quarter evolution (%)

Source: personal contribution

**Table 2: Analysed regions under GEM 2007**

No.	Region	Component countries
1.	CA	Canada
2.	US	USA
3.	CX	OPEC (Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Arabia Saudi, Venezuela), Algeria, Argentina, Australia, Azerbaijan, Bahrain, Brazil, Chile, Indonesia, Mexico, New Zealand, Norway, Oman, Russia and South Africa
4.	AS	China, Hong Kong, India, South Korea, Malaysia, Philippines, Singapore and Thailand
5.	RC	EU25 and Japan

Source: adaptation after Lalonde R., Muir D., op.cit., 2007, p. 111.

**Table 3: GEM 2007 key parameters**

Parameter	CA	US	CX	AS	RC
Preference rate in time $(1/\beta^4 - 1)*100$	1.9	1.9	1.9	1.9	1.9
Depreciation rate $\delta$	0.02	0.02	0.02	0.02	0.02
Inter-temporary substitution elasticity $1/\sigma$	0.7	0.7	0.7	0.7	0.7
Consumption traditions $b_c$	0.85	0.85	0.85	0.85	0.85
Labour elasticity <sup>1</sup> $1/\xi$	0.2	0.2	0.2	0.2	0.2
Share liquidity constraint on consumption SLC	0.2	0.2	0.2	0.2	0.2
Labour traditions $b_l$	0.75	0.75	0.75	0.75	0.75

<sup>1</sup> **Frisch Ragnar**, A complete scheme for computing all direct and cross demand elasticities in a model with many sectors, *Econometrica* 27, 1959, pp. 177-196.

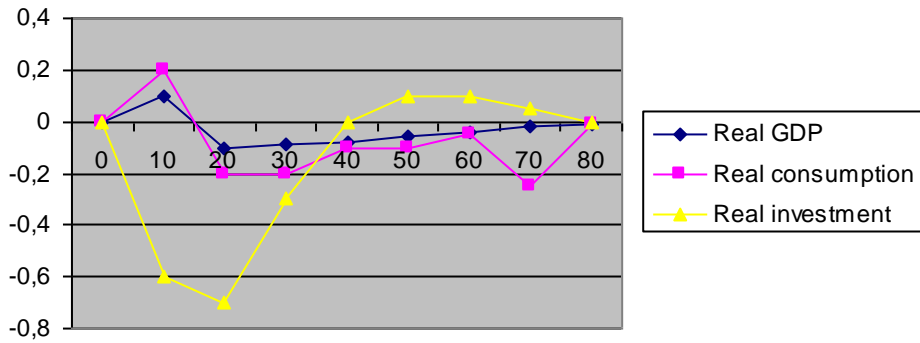


Figure 5: GDP, consumption and investment quarter evolution in Canada (%)

Source: personal contribution

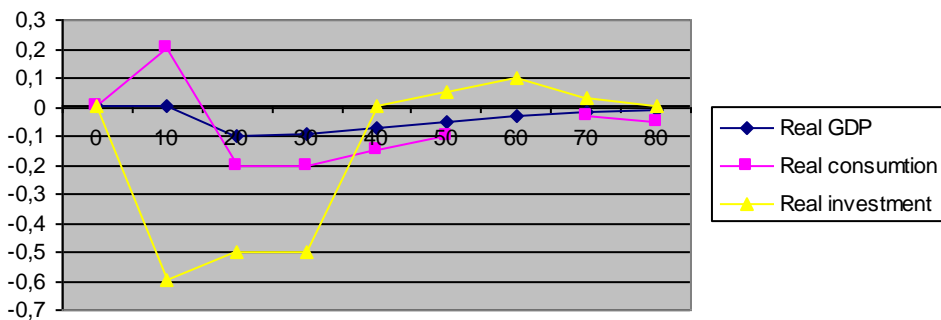


Figure 6: GDP, consumption and investment quarter evolution in USA (%)

Source: personal contribution



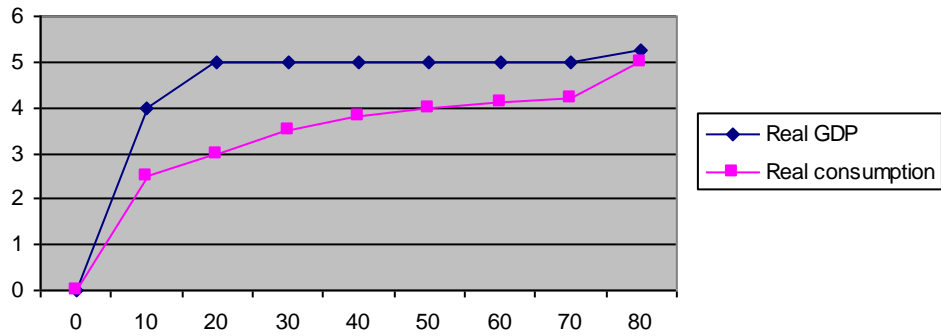


Figure 7: GDP and consumption quarter evolution in the Asian emergent economies (%)

Source: personal contribution

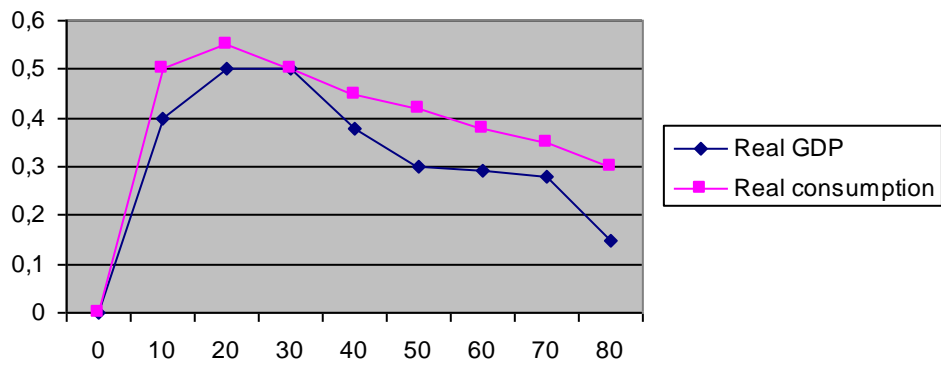


Figure 8: GDP and consumption quarter evolution in the EU and Japan (%)

Source: personal contribution