Review of Business and Economics Studies

REVIEW OF BUSINESS AND ECONOMICS STUDIES (ROBES) is the quarterly peer-reviewed scholarly journal published by the Financial University under the Government of Russian Federation, Moscow. Journal's mission is to provide scientific perspective on wide range of topical economic and business subjects.

CONTACT INFORMATION
Financial University
Leningradskiy Av. 51 Building 3,
125993 Moscow
Russian Federation
Telephone: +7(499) 943-95-23

AUTHOR INQUIRIES
Inquiries relating to the submission of articles can be sent by electronic mail to robes@fa.ru.

ISSN 2308-944X

Вестник исследований бизнеса и экономики

Издательство Финансового университета
125993, Москва, ГСП-3, Ленинградский проспект, 51, корп. 3, к.104.
Тел. 8 (499) 943-95-23.

Журнал «Review of Business and Economics Studies» («Вестник исследований бизнеса и экономики») зарегистрирован в Федеральной службе по надзору в сфере связи, информационных технологий и массовых коммуникаций 9 июля 2013 г. Свидетельство о регистрации ПИ № ФС77-54658.

Подписано в печать: 24.09.2013.
Формат 60 × 84 1/8.
Заказ № 36 от 25.09.2013.

Отпечатано в ООП (Настасьинский пер., д. 3, стр. 1) Издательства Финуниверситета.

16+

Review of
Business and
Economics
Studies

Volume 1, Number 1, 2013

CONTENTS

Вестник исследований бизнеса и экономики

№ 1, 2013

СОДЕРЖАНИЕ

Multicriterial Assessment of RES- and Energy-Efficiency Promoting Policy Mixes for Russian Federation*

Alexander DIDENKO, Ph.D.
Deputy Dean, International Finance Faculty, Financial University, Moscow
alexander.didenko@gmail.com

Abstract. We focus on assessing RES- and energy-efficiency promoting policy mixes for Russia from multicriteria perspective with emphasis on GHG emission reduction. We start from two surveys: the first one studies country's energy saving and RES potential to determine possible range of outcomes for policy mixes in question; the second one reviews corpus of relevant official documents to formulate policy alternatives, which the policymakers are facing. Our findings are then blended with forecasts of government and international agencies to obtain three scenarios, describing possible joint paths of development for Russian energy sector in the context of demographic, economic and climatic trends, as well as regulatory impact from three policy portfolios, for period from 2010 (baseline year) till 2050. Scenarios are modeled in Long-Range Energy Alternatives Planning (LEAP) environment, and the output in the form of GHG emissions projections for 2010–2050 is obtained. We then assess three policy portfolios with multi-criteria climate change policies evaluation method AMS. Our analysis suggests that optimistic scenario is most environmentally friendly, pessimistic one is easier to implement, and business-as-usual balances interests of all stakeholders in charge. This might be interpreted as an evidence of lack of governmental regulation and motivation to intervene in energy sector to make it greener and more sustainable. Research was done with support of grant under European Union FP7 program PROMITHEAS-4 "Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios".

Аннотация. В данной статье методы многокритериального принятия решений применяются для оценки эффективности государственной политики РФ в области развития возобновляемых источников энергии (ВИЭ) и повышения энергоэффективности. Особый акцент при оценке политики делается на достигаемые ей уровни сокращения выбросов парниковых газов. Для этого сначала предпринимается оценка потенциала страны в области энергоэффективности и развития ВИЭ. Затем анализируется законодательство страны, как уже принятое, так и планируемое, для определения спектра возможных альтернатив в области политики. Выводы затем дополняются прогнозами, взятыми из официальных государственных и международных источников, на основании чего строятся три сценария, описывающие возможные траектории развития российской энергетики в контексте демографических, экономических и климатических трендов, а также регуляторного воздействия государства на период до 2050 г. Моделирование сценариев осуществляется в среде Long-Range Energy Alternatives Planning (LEAP), а результатом являются долгосрочные прогнозы выбросов парниковых газов для российской экономики. Три портфеля политик, реализуемые в рамках сценариев, оцениваются многокритериальным методом принятия решений AMS. Наш анализ свидетельствует, что наилучшие показатели по сокращению выбросов имеет оптимистический сценарий, пессимистический — проще в реализации, а базовый — балансирует интересы вовлеченных сторон, имеющих доступ к принятию стратегических решений. Это можно рассматривать как свидетельство недостатка государственного регулирования и мотивации к вмешательству в дела энергетического сектора в целях устойчивого развития в России.

Key words: regulatory impact assessment, multi-criteria evaluation, MCDA, AMS, MAUT, SMART, long-range energy alternatives planning (LEAP), climate policy, climate change, energy policy, mitigation/adaptation, RES promotion, energy efficiency, GHG emissions.

* Многокритериальная оценка государственной политики Российской Федерации в области возобновляемых источников энергии и энергоэффективности

INTRODUCTION

The integration of renewable energy sources (RES) into Russian energy system and improving the energy efficiency of Russian economy and further transition to the low-carbon economy are among the most important topics for Russian and international policy makers. Many social, economic and technological factors have significant influence on development and evolution to the low carbon economy in Russia.

A comprehensive review of computer tools for analyzing various national energy systems was presented by Connoly *et al*. (2010). Authors considered 37 different computer packages that can be used to generate scenario prediction for development of national energy systems and finally concluded: "LEAP would be more suitable due to ... lengthy scenario timeframe".

LEAP (Long-Range Energy Alternatives Planning) is an integrated modeling tool for analyzing energy consumption, transformation and production in all sectors of national economy. The Stockholm Environmental Institute and its US office in Boston developed LEAP in 1980 and now more than 5000 institutions all over the world use LEAP in their research. LEAP contains technological and environmental database (TED), which allows to input and process national economy and energy system datasets.

To compare different scenarios for development of national economy and energy system the efficient multi-criteria evaluation methods should be selected. In analysis of possible scenarios we used the multi-criteria climate change policies evaluation method AMS, combining MCDA procedures AHP, MAUT and SMART, developed by Konidari *et al.* (2007, 2008).

The rest of the paper is organised as follows. In the next two chapters we briefly survey energy-efficiency/RES potential and energy policy options currently being in the centre of discourse among Russian policy makers. Then we proceed with description of scenarios as were modeled in LEAP. Finally, we assess results of our simulation with AMS climate policy multicriteria decision-making tool.

RES POTENTIAL AND ENERGY EFFICIENCY

RES potential. Today in Russia the total installed capacity of electricity generation plants and power plants using renewable energy (without the hydroelectric power plants with installed capacity of more than 25 MW) do not exceed 2200 MW. No more than 8.5 billion kWh of electricity has been produced annually with RES, which is less than 1 percent of total production of electricity in the Russian Federation. The volume of technically available renewable energy sources in the Russian Federation is higher than 3220 Mtoe. However, due to the world energy market conditions and the modern technology restrictions only a small part of available renewable energy sources, excluding hydropower, is feasible without state subsidies. The feasible potential of renewable energy sources in Russia is around 189 Mtoe, including: geothermal sources 80 Mtoe, small hydro sources 45.6 Mtoe, biofuel sources 25.5 Mtoe, solar sources 8.75 Mtoe, wind sources 7 Mtoe, low temperature energy applications 25.5 Mtoe.

In the past support for RES has been poor in Russia. Only in November 2009, the national energy policy included a mandate for increasing RES energy generation from less than 1% to 4.5% by the year 2020 leading to additional 22 GW (Government of Russian Federation *et al.*, 2009), estimated by EBRD (2009). Russian experts in 2008 estimated that the amount of economically recoverable renewable energy is more than 270 million tons of coal equivalent (Mtce) per year, including 115 Mtce/y of geothermal energy, 65 Mtce/y of small hydropower, 35 Mtce/y of biomass, 12.5 Mtce/y of solar, 10 Mtce/y of wind and 31.5 Mtce/y of low potential heat (European Parliament, 2008). More recent estimates refer to technical resource of about 4.5 billion Mtoe with a major share attributed to solar and wind energy (EU-Russia Energy Dialogue, 2011). The corresponding economic potential is estimated at approximately 450 Mtoe (EU-Russia Energy Dialogue, 2011). These figures are mentioned also at "The Main Directions of the State Policy in the Energy Efficiency of RES Electricity for the Period up to 2020 (No.1-r)". The large RES potential is utilized to a small extent by large hydropower and wood energy use. In 2009, electricity generation based on RES (excluding large hydro power stations) was 6,75 TWh (less than 1% of total power generation) and including large hydro power plants — approximately 170 billion kWh (or almost 16% of the total energy mix) (EU-Russia Energy Dialogue, 2011).

Estimations refer to an increase of RES-based power production and consumption volume ratio (excluding hydro power stations with established capacity over 25 MW) from 0.5% in 2008 to 2.5% by 2015 and 4.5% by 2020 (EU-Russia Energy Dialogue, 2011).

One of the greatest Russian energy resources accounting in year 2009 for approximately 21% of the total generating capacity is water, although it corresponds to about 16% of production. In 2009 the country was the world's fifth largest producer of hydropower with approximately 167 TWh/yr, but only 18% of its hydropower potential was developed (EBRD, 2009).

Estimations of the total hydropower technical potential refer to about 2,400 billion kWh per year, the majority of which is based on medium and large rivers. The respective economic potential is 850 billion kWh per year (EBRD, 2009). Small hydro is the most mature RES type in the country. The potential of smaller rivers amounts to approximately 46% of total hydro energy potential (European Parliament, 2008).

Most of this potential is located in Central and Eastern Siberia and in the Far East. The Far East and Eastern Siberia combined account for more than 80% of hydropower potential, and could produce about 450–600 billion kWh per year (EBRD, 2009). The North Caucasus and the western part of the Urals also have good hydropower potential. Installed capacity amounts to 1,000 MW (European Parliament, 2008).

There is also rather high potential for wide and effective use of biomass resources since Russia has approximately 22% of the world's forests located on its territory (EBRD, 2009; European Parliament, 2008). The forest industry is an important Russian economic sector, a large potential supplier and consumer of biomass (wood waste) products. These products are only being minimally exploited. The technical potential of biomass is estimated at more than 50 Mtce.

Apart from the forestry sector, the agricultural sector is also an important source of biomass resources, but the vast majority of Russia's agricultural resources are not being used at all. An estimated 850 million liters of biofuel could be produced on this territory.

The majority of the energy produced from biomass has been used for heating purposes, and not for power generation although it is considered as most suitable solution for power production and for cogeneration of heat and electricity (European Parliament, 2008; EBRD, 2009). Approximately 40 thermal power stations use biomass (mostly waste from the wood processing industry) along with other fuels. Biomass is also used as solid fuel in certain district heating boilers being a potential niche market for biomass in the district heating systems. Installed capacity (until year 2008) accounted for 1,270 MW (European Parliament, 2008).

The technical potential of solar energy was estimated as $18.7*10^6$ GWh, with an economic potential around $1*10^5$ GWh per year (EBRD, 2009). Some areas receive more than 300 sunny days per year, and the cold temperatures also improve the efficiency of solar cells.

Russia possesses vast geothermal resources, and over 3,000 wells have been drilled to take advantage of this renewable energy type. Geothermal energy is used for heat supply and electricity production. In 2009 there were 92–129 MW of geothermal power plants operating, and about 55 MW of planned additional capacity (EBRD, 2009).

Up to 2009, Russia had only over 20 MW of wind, and new wind turbines had not been built since 2002. Estimated gross wind potential is 26,000 million tons of coal equivalent, technical potential is 2,000 Mtce, and economic potential — 10 Mtce. Approximately 30% of this economic potential is concentrated in the Far East, 16% in West Siberia and another 16% in East Siberia (EBRD, 2009).

Most of Russia's tidal power is dissipated in the Arctic regions, in particular the White Sea is considered to have a great potential. In the Mezen Bay, the difference between low tide and high tide is greater than 20 feet.

In 2007, a 1.5 MW tidal power plant by Gidro OGK began operation as a pilot project in the same bay. In case of success, the company plans 10 GW of electricity generation, and potentially to build several more tidal electro stations in other Russian bays (EBRD, 2009).

Energy efficiency. According to MED, energy efficiency in Russia is significantly lower compared to developed countries. According to information of Ministry of Energy, total energy consumption in Russia averages to about 990 millions of standard fuel tons. If Russia would implement energy saving to a scale common for European Union countries, its energy consumption would fall by 35% to 650 millions of tons of standard fuel. Energy intensity of GDP in Russia is 250% higher than world average and 250–350% higher than in developed countries (GPEE-2020). Bashmakov (2009) provides sectoral estimates of energy saving potential for Russia. The technical potential in the transportation sector is approximately 38.30 Mtoe. The potential in both heat and electricity generation will be the outcome of efficiency improvements at the generation facilities and reductions of power- and heat end-use. In electricity generation, the potential is 93 Mtoe, and in the heat supply sector — 107 Mtoe, while the potential of fuel production and transformation efficiency improvement is 41 Mtoe.

Estimations of the technical potential in electricity of the residential buildings refer to reductions of energy use for the following applications: 25.5% for space heating; 51.9% for hot water; 29.1% for cooking; 78.8% for lighting; 23.5% for appliances (refrigerators and freezers, washers, VT and video, air conditioners and other appliances).

POLICY OPTIONS FOR MITIGATION POLICIES IN RUSSIA

Analysis of relevant government documents shows that in Russia climate change mitigation and adaptation discourse almost is not reflected in official national climate strategy documents and climate-related laws, especially in terms of measurable goals and actionable plans. However Russia has very developed and complex structure of government-adopted and parliament-voted documents for RES promotion and energy efficiency, from high-level strategic documents and laws to low-level federal programs, bylaws, rules and regulations. As these policies could potentially impact GHG emissions, we interpret it as climate change policies.

Historically, first targets for increasing the use of RES and energy-efficiency were set in the following federal programmes: "Energy Efficient Economy for 2002–2005 and Period until 2010" (adopted by government on 17.11.2001); "South of Russia" (adopted by government on 8.08.2001); "Economic and Social Development of Far East and Baikal Region" (adopted on 15.04.1996) (Helio International, 2006).

The "Energy Strategy of Russia up to 2020" (Government decree No.1234-r issued on 28.08.03) was the first strategic energy program in RF. It emphasized increasing energy efficiency and implementation of proper energy pricing policy to overcome country's heavy dependence on natural gas. Its share in energy balance was about 50% during the 1990s. The "Energy Strategy 2020" proposed a wider use of coal and nuclear energy with an anticipated share in year 2020 of 21–23% and 6% respectively (Helio International, 2006).

In 2005 the "Integrated Action Plan for Implementation of Kyoto Protocol in RF" was approved by the Interdepartmental Commission. It was a detailed action plan for the period up to 2010 with quantifiable goals and workable plans as follows:

- Energy Strategy of RF until 2020 (Decree of the Russian Federation, No.1234-r, August 28, 2003);
- Federal Program "Energy Efficient Economy" for 2002–2005 and up to 2010 (Decree of the Russian Federation No.83-p, January 22, 2001);
- Draft Program of socio-economic development of the RF in the medium term (2005–2008);
- Federal Program "Modernization of Transport System of Russia (2002–2010)" (Decree of the Russian Federation, No.232-p, February 16, 2001).

As for energy efficiency and RES usage it sets the following targets:

- Energy consumption in the transport sector was expected to be restricted from 9.3 Mtce in 2004 to 10.3 Mtce in 2008 (goal was initially set in Federal Program "Modernization of Russian Transport System (2002–2010)");
- Reduction of specific fuel consumption for electricity generation in power plants of RAO "UES of Russia" was set at 8% for the period 2004–2008 (Energy Strategy of RF until 2020);
- Gas transmission and distribution losses from upstream to distribution were expected to be reduced by 47 billion m^3 for the time interval 2006–2010 (initially set by Federal Program "Energy Efficient Economy" for 2002–2005 and up to 2010);
- The share of renewable energy in total primary energy production was expected to be increased from 0,1% to 0.22%-0.3% in 2010 (initially set by Federal Program "Energy Efficient Economy" for 2002–2005 and up to 2010).

The Presidential Decree No. 889 "On some measures to improve the energy and environmental efficiency of RF economy" was approved on June 4, 2008. It is a brief document, containing only one important quantitative goal for energy efficiency: decrease of GDP energy intensity up to 2020 by 40% of 2007 level. It also contains several important president's orders to the government, with deadlines, aimed at achieving the mentioned goal.

The adoption of "The Main Directions of The State Policy in the Energy Efficiency of RES Electricity for the Period up to 2020 (No.1-r)" on January 8, 2009, became the next step, which declared the purposes and principles of RES use in RF, set quantitative targets for the share of RES electricity production/consumption in the total energy balance and defined the measures to achieve them. The document deals explicitly with the supply side of electricity balance; expands and refines goals for the Action Plan about RES by setting the following targets for RES-generated electricity (except for electricity generated by hydro power plants with power exceeding 25 MW): by 2010–1.5%, by 2015–2.5%, by 2020–4.5% share in total electricity generation.

The Climate Doctrine of RF (CD RF) (approved by Presidential Decree No.864p on December 17, 2009) is a short framework paper, describing briefly and in general terms the main notions of climate policy in RF, declaring risks and positive outcomes of global climate change for the country, wide categories of mitigation/adaptation instruments, etc. It contains not quantitative, but qualitative goals.

The "Energy Strategy for the Period of 2030", adopted in 2009, is an updated version of the previously mentioned "Energy Strategy 2020". It analyses the level of accomplishment of the previous Strategy and contains further details and expanded goals. Specifically, it points out that non-realized potential for energy intensity for Russian economy could be equal to 40% of domestic energy consumption.

The "Energy Strategy 2030" breaks down this potential into various components, namely:

- Residential buildings — 18–19%;
- Power generation, industry, transport — 13–15% each;
- Heating, services, construction — 9–10% each;
- Fuel production, gas flaring, energy government agencies — 5–6% each;
- Agriculture — 3–4%.

The "Energy Strategy 2030" sets a 56% energy intensity reduction target for 2030 (compared with year 2005). To reach this goal Russia plans to create a favourable economic environment, including progressive liberalization of energy prices on the domestic market; to promote more rational energy use, and to establish a market for energy services. New standards, tax incentives and penalties, as well as energy audits need to be adopted. The "Energy Strategy 2030" also aims to increase the energy efficiency of buildings by 50% for the time interval 2008–2030 (+10% for the period 2008–2015) by implementing new mandatory construction standards.

Finally, the state program "GPEE-2020" ("Energy saving and improving energy efficiency for a period up to 2020") was approved by the Government of Russian Federation on 27.12.2010. This program aims to decrease GDP energy intensity by 13.5%, and save up to 100 millions of standard fuel per year by 2016 and 195 millions of standard fuel per year by 2020. This goal has the following sectoral subgoals (in terms of total energy savings).

SCENARIO ASSUMPTIONS

Scenarios reflecting various paths for energy and economy development in Russia are modeled in LEAP. Long-Range Energy Alternatives Plannning (LEAP) is modeling environment, which allows to create simulation models of energy economy of certain region. It is a well established tool, used many times both by practitioners and academicians (see, for example, Konidari & Mavrakis (2007), Miranda-da-Cruz (2007), Cai, Huang, Lin, Nie & Tan (2009), Kalashnikov, Gulidov & Ognev (2011), Tao, Zhao & Changxin (2011), Zhang, Feng & Chen (2011), Shan, Xu, Zhu & Zhang (2012), Ke, Zheng, Fridley, Price & Zhou (2012)). Basic idea is as follows: we populate historical energy balances for Russia in LEAP with data from EIA; we set energy consumption structure in economy according to historical data from Rosstat; we add historical trends, reflecting changes in temperature, precipitation, country population and GDP.

We further define three scenarios: (1) business-as-usual (BAU), serving as baseline for (2) optimistic (OPT) and (3) pessimistic (PES) scenarios. Basic assumptions about economic activity, energy sec-

Table 1. Sectoral targets for energy efficiency.

Sector	Goal for 2011–2015	Goal for 2011–2020
Primary energy	334 million tons of standard fuel	1124 million tons of standard fuel
Natural Gas	108 billion m^3	330 billion m^3
Electricity	218 billion kWt/h	630 billion kWt/h
Heat	500 million Gcal	1550 million Gcal
Oil and products	5 million tons	17 million tons

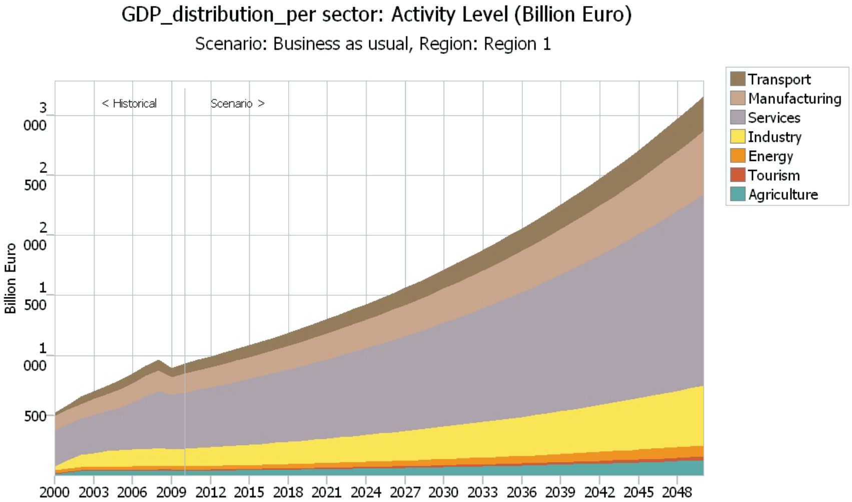


Figure 1. Sectoral distribution of output, BAU scenario.

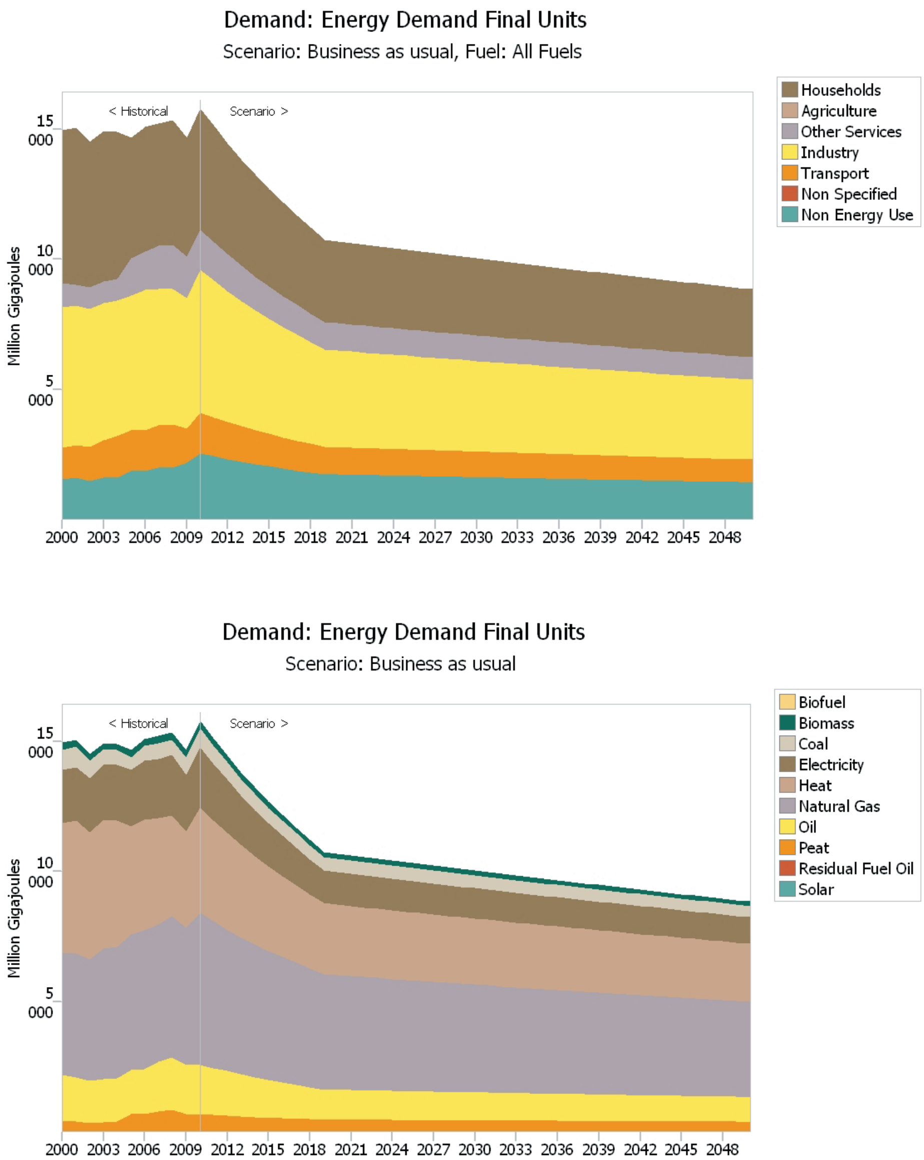


Figure 2. Total demand for energy 2011–2050 broken down to sectors (above) and sources of energy (below).

tor development paths, demography and climate for these scenarios are based on official estimates of either government or various international agencies and organisations (World Bank, IMF, UN). We use historical trends as a kind of reality check for plausibility of basic assumptions. BAU scenario contains moderate estimates of basic assumptions variables and reflects only regulations and national energy strategy, adopted and actually enacted on December 31, 2010. As for basic assumptions in OPT and PES scenarios, we used the most optimistic of all available options for OPT (the milder path for warming, better demography and GDP, innovational scenario and forced speed of development for energy sector), and the most pessimistic for PES (slower implementation of innovations, low GDP growth rate, severe climate change, bad demography). OPT and PES scenarios reflect augmented set of policies, based on what is actually discussed by government, as if it was adopted in 2011–2013 and further applied to economy and energy sector. OPT assumes that policies are implemented faster with better results, and PES — that it is implemented slower with worse results.

Using trends for economic activity detailed assumptions about sectoral structure of energy consumption (based on historical values), LEAP projects sectoral energy consumption for period 2010–2050. Using built-in technology database and energy intensity, LEAP defines GHG emissions levels for period mentioned. GHG emissions forecast is main output of LEAP model. We further use it as an input in AMS climate policy assessment procedure.

Business-as-usual (BAU) scenario. BAU-scenario is built on policy portfolio effective as of December 31, 2010, as well as scenario assumptions, grounding forecasts of government of RF and international organisations.

Population dynamics in BAU-scenario follows dynamics from scenario of "Long Term Forecast of Social-Economic Development of Russian Federation for a Period of up to 2030".

Forecast contains several scenarios for population. For BAU moderate rate forecast was selected. According to this scenario slight decrease in population is expected in 2020–2025, with subsequent recovery to 2010 level in 2030. After 2030 we assume population stabilizes and remains unchanged till 2050.

In 2008 Roshydromet published "Report on Climate Change and its Consequences in Russian Federation". Report notes beginning of a trend of temperature rise since beginning of 21 century. According to Roshydromet estimates, average temperature rise till 2050 in Russian Federation could be from 1 to 6 degrees Celsius, with probability of standard deviation quite high.

Roshydromet estimates are confirmed by several research organisations in Russia and abroad. Roshydromet/RAS Institute of Global Climate and Ecology, with participation of Hydrometcentre and other state-funded research organisations, published global scenario forecasts for climate change up to 2020, 2050, and 2080. Average temperature is estimated with ensemble of models, and deviation of predicted values could be up to 3 degrees Celsius. In our research we average historical values

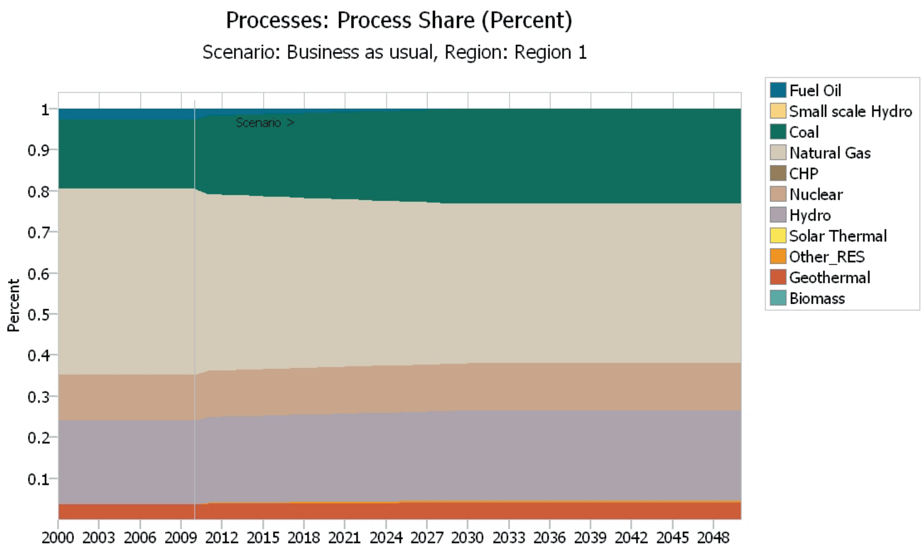


Figure 3. Historical levels and forecast for 2000–2050 of electricity generation: BAU-scenario, energy sources breakdown.

for temperature and precipitation for 1901–2009, published by World Bank, and long-term forecasts of Roshydromet and RAS. Average surface temperature for RF was about –5 degrees Celsius, according to World Bank.

Along with that, significant volatility of temperature around average level was observed, but generally during 20th century trend was horizontal, and only in 1990s and in the beginning of 21th century upward slope was observed. Taking average for 20th century as baseline, we build BAU-scenario with linear increase of average yearly temperature up to +3 degrees in 2050, which is in line with moderate forecasts of Roshydromet and RAS.

According to World Bank, long-term average level of precipitation was 460 mm. We take this level as baseline, and use RAS assumptions to model yearly change in precipitation.

Unlike scenarios for surface temperature, assuming significant changes, precipitation was assumed not to change significantly. In BAU we assume total decrease in average level of precipitation by 2 mm during all the period.

GDP as indicator of economic activity is key factor for forecasting GHG emission. In Russia this interplay is even tighter, moderated by low energy efficiency and significant role of energy sector in economy. GDP dynamics, with energy-efficiency dynamics and structural change in economy is thus key factors of energy demand and, accordingly — GHG emissions. In BAU GDP change is modeled as follows. GDP growth in 2011–2012 is assumed to be equal to historical estimates according to state statistics (in 2010–4.3%, in 2011–3.4%, in 2012–2.4%). After 2012 GDP growth rate is assumed to be equal to constant rate of 3.1%, which is in line with conservative forecast of the government of RF. We assume in BAU that this rate will persist over period of 2030–2050. Sectoral distribution of GDP will follow this dynamics too (Figure 1).

Energy efficiency. Basis for energy efficiency modeling is historical data by EIA and forecasts of state program for energy efficiency till 2020. Program has two scenarios: innovational and inertial. For BAU scenario we used inertial scenario of the program. After achieving goals of state program in 2030, energy efficiency is assumed to remain unchanged. Given that Russian economy is one of the most energy inefficient in the world, in 2030 it will still have huge potential for improving energy efficiency.

Oil and natural gas prices. Oil and gas prices are modeled according to IEA World Energy Outlook for 2010.

Energy consumption. For this section inertial scenario of Federal Target Program "Energy saving and energy efficiency till 2020" was adopted. It is assumed that after 2020 increase in energy consumption intensity will continue with twice as lower rate as during realisation of federal target program. Accounting for increase in energy efficiency total demand for energy with sectoral and energy source breakdown will look as follows (Figure 2).

Transformation: losses. According to "Energy Strategy 2030", if all measures of the strategy will be rendered, losses in heat generation will be decreased by 50% by 2030, and in electricity generation — by 2% by 2030. Assumptions of the strategy are put in BAU scenario.

Electricity generation. Historical data for primary fuel consumption for electricity generation are taken from "Energy Strategy 2030". This paper assumes achievement of definite structure of electricity generation in 2020 and 2030. In particular, it assumes increase of the share of non-fuel generation, and increase of natural gas and coal share in fuel generation. "Strategy" has no details about structure of all the other sources of electricity generation (nuclear, hydro, small RES, etc.) We model shares of these types of energy as proportional to historical structure of 2010. Change of shares toward numbers set by "Strategy 2030" is obtained by linear interpolation of shares for non-fuel, natural gas, coal and heating oil from levels of 2010. After 2030 structure of generation is assumed to remain unchanged.

OPT scenario, apart from faster realisation, assumes further improvement of structure of generation (Figure 3).

Land management policy mix was considered in the draft federal target program "Development of the reclamation of agricultural land in Russia until 2020", developed in accordance with the decision of the board of the Ministry of Agriculture of Russia No.7 on August 26, 2008, and on the basis of Article 8 of the federal law dated 29.12.2006 No.264-FZ "On the development of the agriculture sector".

RESULTS OF POLICIES SIMULATION AND ITS ASSESSMENT

The graph on Figure 4 displays greenhouse gas emissions by various sectors and types of fuel.

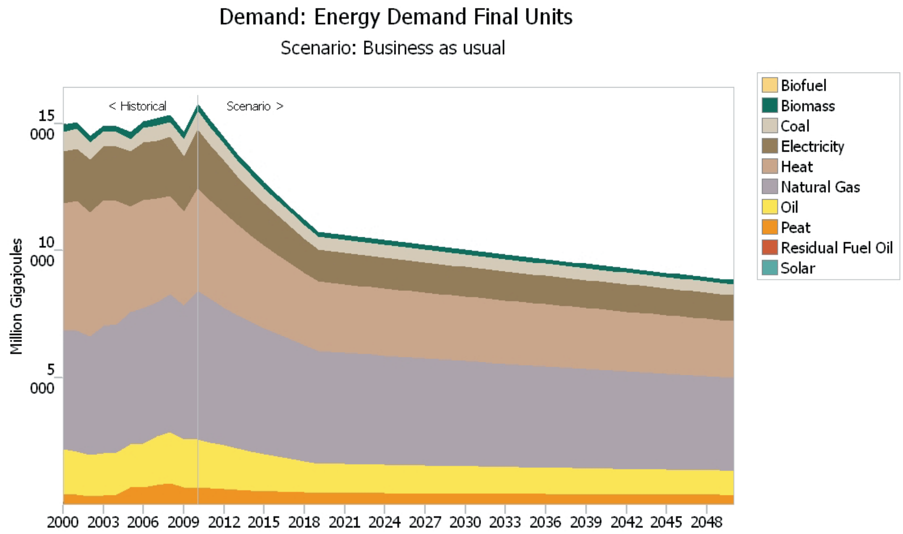


Figure 4. Historical levels and forecast for 2000–2050 of final energy demand: BAU-scenario, fuel type breakdown.

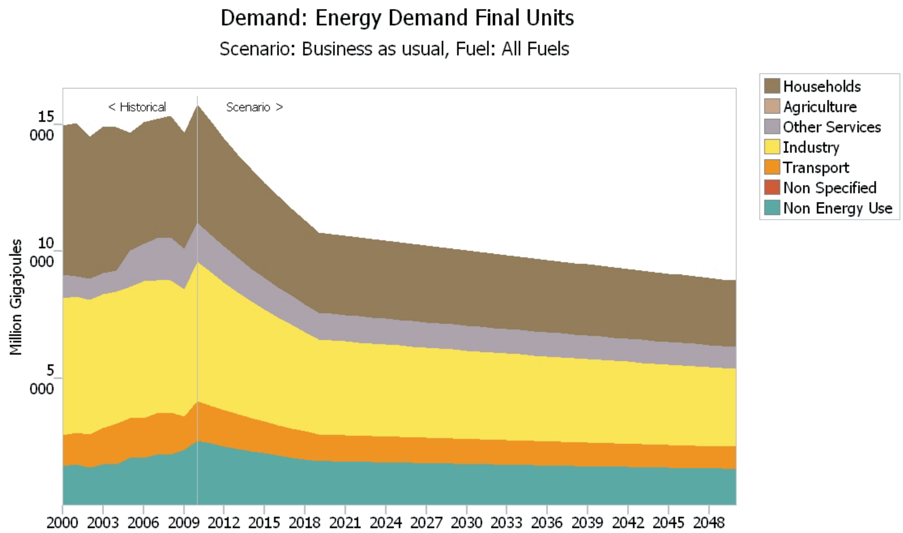


Figure 5. Historical levels and forecast for 2000–2050 of final energy demand: BAU-scenario, sectoral breakdown.

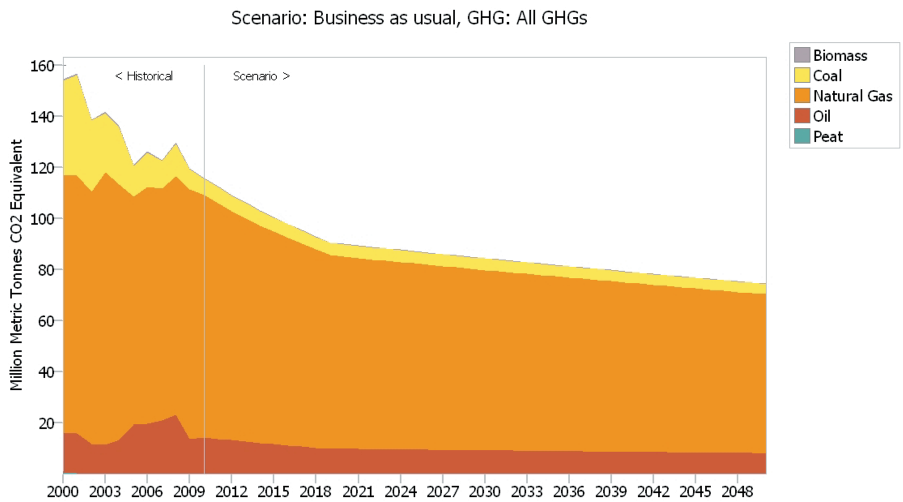


Figure 6. Historical levels and forecast for 2000–2050 of GHG emissions for households sector: BAU-scenario, fuel type breakdown.

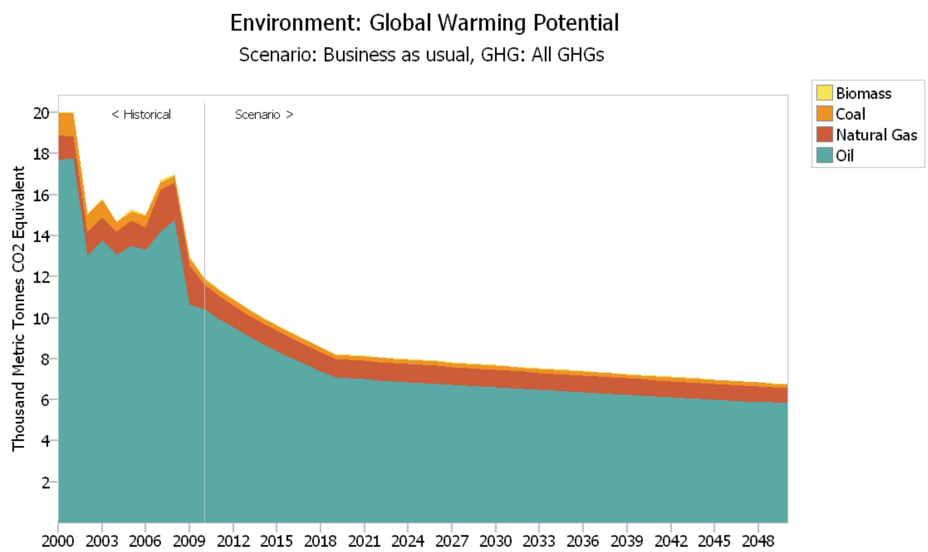


Figure 7. Historical levels and forecast for 2000–2050 of GHG emissions for agriculture sector: BAU-scenario, fuel type breakdown.

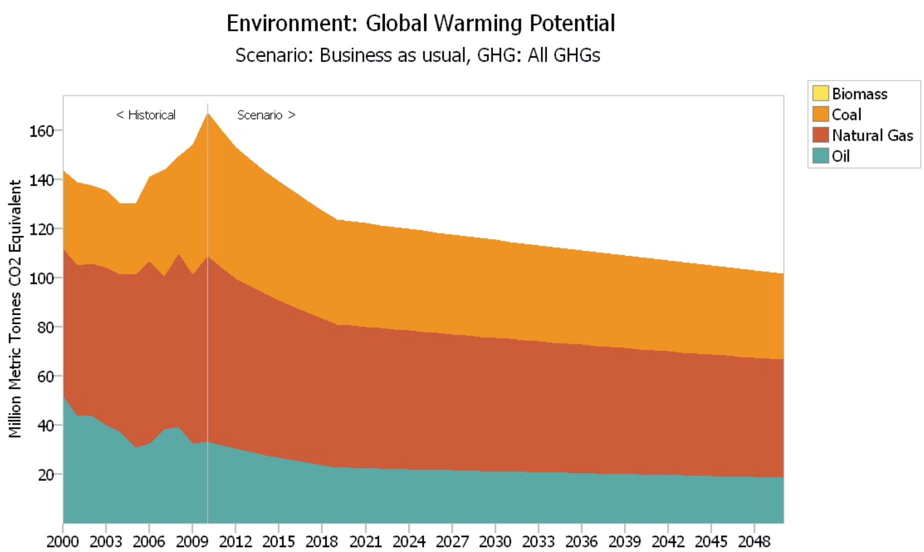


Figure 8. Historical levels and forecast for 2000–2050 of GHG emissions for industry sectors: BAU-scenario, fuel type breakdown.

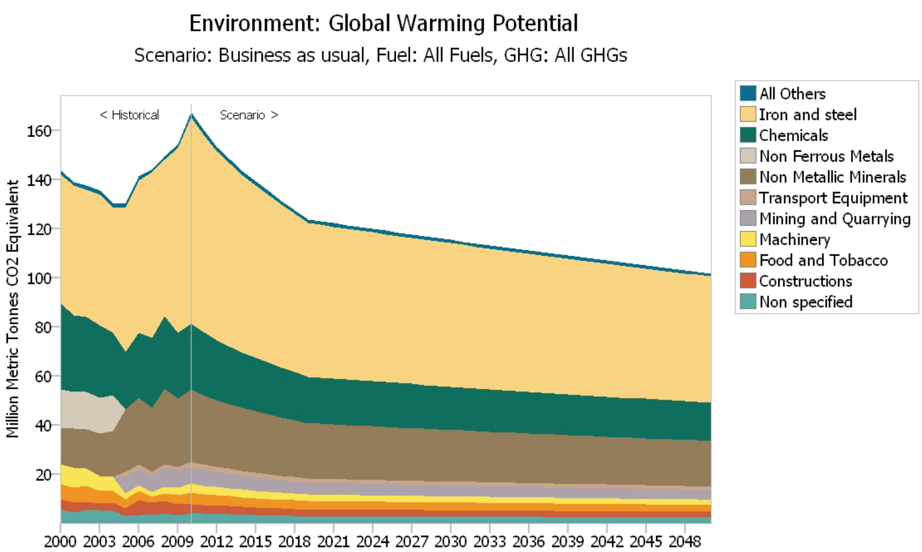


Figure 9. Historical levels and forecast for 2000–2050 of GHG emissions for industry sectors: BAU-scenario, sectoral breakdown.

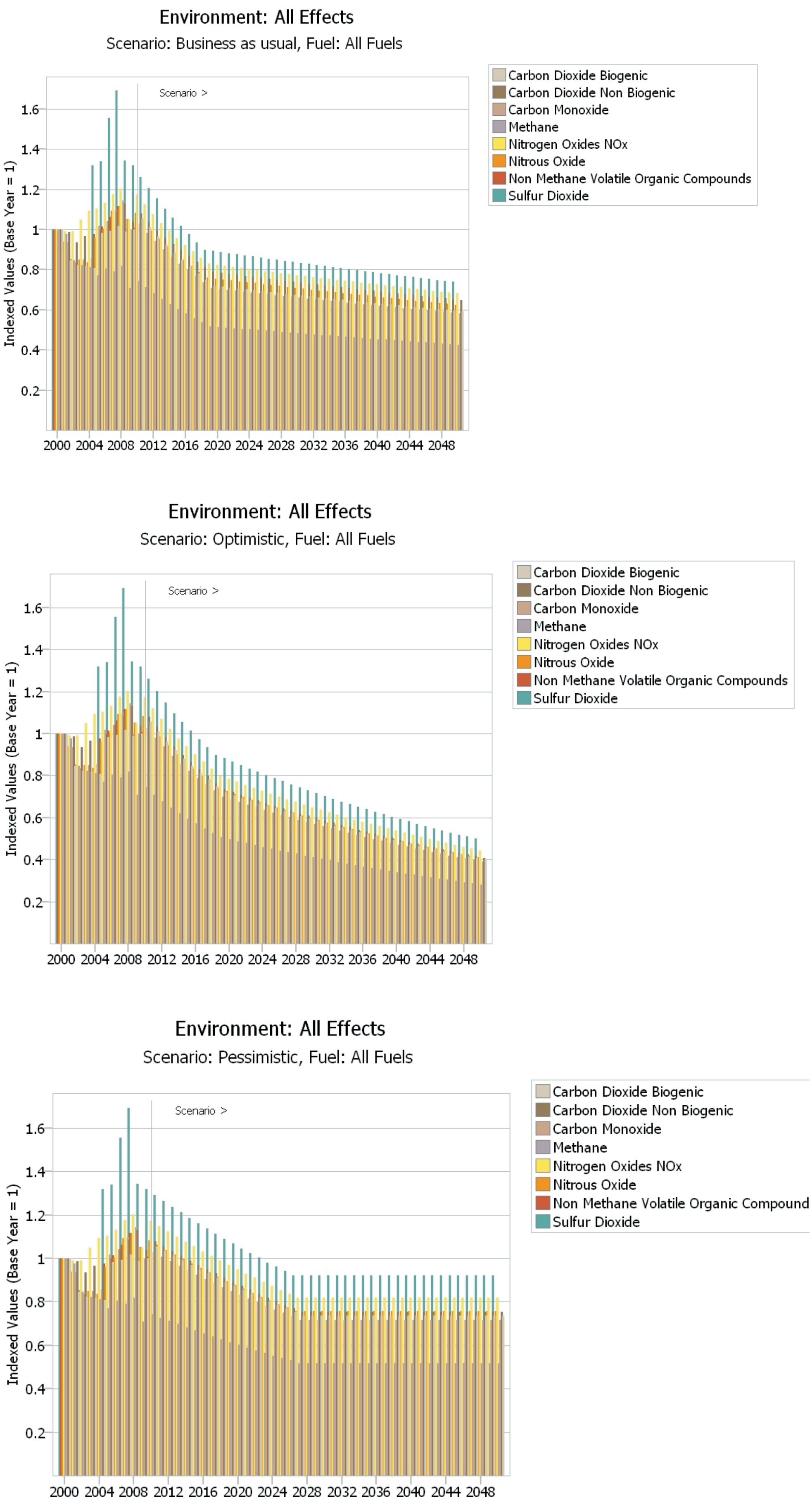


Figure 10. Historical levels and forecast for 2000–2050 of GHG emissions for services sector: BAU-, OPT-, and PES-scenario, all fuel.

AMS-ASSESSMENT OF POLICY MIXES

According to procedure proposed in Konidari (2007, 2012), we use output of LEAP simulation as input in AMS procedure to obtain final grades for various policy mixes in question. Final performance of policy mixes is assessed along following criteria: two subcriterions for environmental efficiency, assessing direct and indirect effects; several sub-criterions for political acceptability — static and dynamic cost efficiency, and competitiveness; equity; flexibility; stringency for non-compliance; and several sub-criterions for feasibility — implementation of network capacity, administrative and financial feasibility. Subcriterions of environmental efficiency are handled as follows: (1) for direct contribution to GHG emission reductions the outcome of LEAP for the total expected GHG emissions in year 2020 is used, and (2) for indirect environmental effects, the total amount of the total environmental effects provided by LEAP is used. For political acceptability criterion, there are following sub-criterions:

- Cost efficiency measures capacity of policy portfolio to achieve target parameters under financial constraints both acceptable and affordable to stakeholder entities. BAU includes the lowest volumes of regulations, many of which already have sources of financing allocated. OPT and PES require more financing, and given this, PES achieves even less reduction than BAU. Consequently, BAU is assigned the highest grade: 6, OPT: 4, PES: 2.
- Dynamic cost efficiency criterion captures opportunities, which certain policy portfolio creates to support R&D, various technologies and innovations leading to GHG emission reductions and lessening the impacts of climate change. In our case, all three scenarios — PES, OPT and BAU — contain parts promoting green (or at least "more green") technologies: energy efficiency, energy saving, smart grid, shift in energy demand, RES, etc.

PES only assumes slower and less effective rendering of such policies compared to OPT. So, both OPT and PES receive high grade for this criterion, 6 each. And BAU receives 4, as it assumes less mentioned technologies.

- Competitiveness criterion is used to assess the impact of certain policy portfolio implementation on the ability of the national economy to compete with other economies both via prices and products/services. Two common factors for economy, affecting all three scenarios, will be the price for oil and climate change. Russia is net exporter of oil, and one of minority of countries supposed to benefit from climate change. Export of oil has generally negative impact on national competitiveness when oil price is higher, both in short and long term, as it keeps ruble high and lowers motivation of industry for modernization. So PES with lower price for oil will score higher and OPT — lower given only oil factor. Climate change is assumed to be more severe in PES case, but consequences are unclear: whether Russian economy will be in position to leverage climate change challenges or will be hurt is a separate research question. Country has no particular emission reduction goals, which are regarded as lowering competitiveness, so no particular impact here. OPT scenario assumes forced implementation of energy-saving technologies and R&D support, which will contribute to higher score

Table 2. AMS results for BAU, OPT and PES scenarios.

	Weight	BAU	OPT	PES	BAU	OPT	PES
Direct contribution to GHG emission reductions	0.833	218.7458	137.9448	254.3982	262.6	165.6	305.4
Indirect environmental effects	0.167	0.8183	0.5344	0.9853	4.9	3.2	5.9
Environmental performance — A		**219.5641**	**138.4792**	**255.3835**			
Cost efficiency	0.473	2.838	1.892	0.946	6	4	2
Dynamic cost efficiency	0.183	0.732	1.098	1.098	4	6	6
Competitiveness	0.085	0.34	0.51	0.425	4	6	5
Equity	0.175	0.875	1.05	0.35	5	6	2
Flexibility	0.05	0.3	0.15	0.15	6	3	3
Stringency for non-compliance	0.034	0.204	0.136	0.136	6	4	4
Political acceptability — B		**5.289**	**4.836**	**3.105**			
Implementation network capacity	0.309	1.854	1.236	1.545	6	4	5
Administrative feasibility	0.581	3.486	2.324	2.905	6	4	5
Financial feasibility	0.11	0.77	0.44	0.55	7	4	5
Feasibility of implementation — C		**4.256**	**2.764**	**3.455**			

of OPT. Summing up, in OPT scenario economy will be more competitive due to higher energy efficiency, lower ruble rate, bigger share of knowledge economy in GDP, and (supposedly) effective use of climate change. On the opposite, competitiveness in PES will be oppressed by high prices for oil, but supported by climate change, which could have positive impact on agriculture competitiveness. The assigned grades are: BAU: 4, OPT: 6, PES: 5.

Equity criterion measures "fairness" of scenario in distributing costs and benefits associated with scenario among entities and citizens of the country. We measure intragenerational equity, social equity and sector equity. Intragenerational equity is measured as total change of GDP per capita divided by total change in emissions (MtCO2eq) per capita over 2010–2050, higher the change — lesser the score. Social equity is emission reduction per capita compared to BAU in 2050. Sector equity is standard deviation of sectoral emissions in each of three scenarios. As for intragenerational equity, PES scenario assumes slight increase in emissions per capita, so preliminary score will be negative and high. OPT and BAU have slightly different and positive change, so total score for social equity will be: OPT — 6, BAU — 5, PES — 0. For social equity, BAU will score 5, OPT — 6, and PES — 4. For sector equity, the lower standard deviation is in OPT scenario, it scores 6, with BAU slightly lower than PES (4 and 3 accordingly). For total equity criterion we will average all scores: BAU — 5, OPT — 6, PES — 2.

Flexibility criterion captures the ability of the policy instruments to offer a range of compliance options. BAU imposes minimal obligation on stakeholders and consequently offers higher flexibility. Due to the similarity of the introduced instruments in PES and OPT, equal grades are given for both. The assigned grades are: BAU — 6, OPT — 3, PES — 3.

Stringency for non-compliance and non-participation reflects the level of sanctions, imposed by regulations in each of the scenarios. Although in all scenarios regulation is quite loose, OPT and PES contain more policy instruments, and therefore should be graded lower. The grades are: BAU — 6, OPT — 4, PES — 4.

Feasibility of implementation has the following subcriterions:

- Implementation network capacity. OPT and PES scenarios contain extra policies as compared to BAU, which assume extra load for existing implementation network. The assigned grades are: BAU — 6, OPT — 4, PES — 5.
- Administrative feasibility is high for BAU, slightly lower for PES and even more lower for OPT. BAU includes well-known instruments, many of which are already being implemented. OPT and PES include more innovational instruments, with OPT including more than PES. The assigned grades are: BAU — 6, OPT — 5, PES — 4.
- For financial feasibility, only BAU has relatively high performance (scored 6). It includes policy instruments associated with federal programs, which guarantees financial recourses pre-allocated. In addition, BAU includes minimal set of policies possible. Financial requirements of OPT and PES are much higher (with OPT being the most financial resource intensive), and financial source is not defined yet. The assigned grades are: BAU — 7, OPT — 4, PES — 5.

DISCUSSION AND CONCLUSIONS

Based on the analysis of official documents and governmental programs, three scenarios of economic development of Russia until 2050 were developed. Mentioned scenarios accounted for greenhouse gas emissions from various sectors of Russian economy.

As part of the research, an econometric model in LEAP environment was built, encompassing fuel and energy balances data, as well as historical and forecasted national GDP, industry and energy structure, sectoral and total energy efficiency, and the demand for energy from sectors of economy was forecasted for up to 2050.

According to the BAU scenario, GHG emissions will be reduced by 22% by 2020 and decrease by 36% by 2050. OPT scenario will achieve reductions in GHG emissions by 28% and 60% in 2020 and 2050, respectively. Analysis of GHG emissions by sectors shows a non-monotonic behavior of the service sector GHG emissions in all scenarios, an increase in GHG emissions in 2020 from 11% to 34% in OPT and PES scenarios respectively. Calculations showed a decrease in energy intensity of GDP in 2020 to 38% for BAU and OPT, and by 22% for the PES scenarios. Modeling showed anticipatory reduction of GHG emissions by households, which reaches in 2050 52%, 72% and 48% for the BAU, OPT and PES respectively.

Final assessment according to AMS procedure could be done as follows. For criterion of environmental performance, OPT offers better grade of all scenarios; PES has the lowest, and BAU is in the middle. This could be interpreted as lack of regulation (driven, perhaps, by lack of motivation) of regulatory bodies to decrease environmental impact of Russian economy. There is definitely great leeway for improving environmental performance of the economy through implementation of new policies, many of which are currently discussed.

In line with above-mentioned considerations, and as probable explanation to it, BAU has greatest score for political acceptability, combining better cost efficiency, better flexibility and lowest sanctions level with moderate equity and competitiveness features. BAU could be regarded as *status quo*, maximizing egoistic utility of stakeholders having access to political power for reflecting their interest in policy. OPT scenario features more high-tech and green options, as it offers less natural resources-heavy options at the expense of more financial resources involved. Still it could find some political support in Russia, and it scores as the second. PES is less cost-effective both in static and dynamic aspects, it offers much less equity than OPT, and less competitiveness than BAU. Being a kind of loose-loose outcome in political aspect, it scores the third.

In addition to being the most politically acceptable, BAU has also the greatest score for feasibility of implementation. PES involves less modernization and regulatory activity, therefore it is more feasible than OPT, although less than BAU. OPT has less feasible policy mix of all three scenarios. To sum up, OPT is the most environmentally friendly, PES is easier to implement, and BAU balances interests of all stakeholders in charge.

REFERENCES

Bashmakov, I. (2009), "Resource of energy efficiency in Russia: scale, costs, and benefits", *Energy Efficiency*, *2* (4), 369–386.

Cai, Y. P., Huang, G. H., Lin, Q. G., Nie, X. H., & Tan, Q. (2009), "An optimization-model-based interactive decision support system for regional energy management systems planning under uncertainty", *Expert Systems With Applications*, *36* (P2), 3470–3482.

Caspary, G., Evans, M., & Buxtorf, L. (2007), "Stabilising energy-related greenhouse gas emissions: Making "technology wedges' feasible", *Renewable Energy*, *32* (5), 713–726.

Connolly, D., Lund, H., Mathiesen, Leahy, M. (2010), "A Review of Computer Tools for Analysing the Integration of Renewable Energy into Various Energy Systems", *Applied Energy* **87**, pp.1059–1082.

Government of Russian Federation, Institute of Energy and Finance, Institute of Energy Strategy, Institute of Energy Research, Institute of High Energy Densities, RAS, Institute of Petroleum Geology, *Energy Strategy of Russia for the period up to 2030*.

Kalashnikov, V., Gulidov, R., & Ognev, A. (2011), "Energy sector of the Russian Far East Current status and scenarios for the future", *Energy Policy* ***39*** (11), 6760–6780.

Ke, J., Zheng, N., Fridley, D., Price, L., & Zhou, N. (2012), "Potential energy savings and CO_2 emissions reduction of China's cement industry", *Energy Policy* **45** (C), 739–751.

Konidari, P., & Mavrakis, D. (2006), "Multi-criteria evaluation of climate policy interactions", *Journal of Multi-Criteria Decision Analysis* **14**, pp. 35–53.

Konidari, P., & Mavrakis, D. (2007), "A multi-criteria evaluation method for climate change mitigation policy instruments", *Energy Policy* **35**, pp. 6235–6257.

Kumbaroğlu, G., Madlener, R., & Demirel, M. (2008), "A real options evaluation model for the diffusion prospects of new renewable power generation technologies", *Energy Economics*, ***30*** (4), 1882–1908.

Miranda-da-Cruz, S. M. (2007), "A model approach for analysing trends in energy supply and demand at country level: Case study of industrial development in China", *Energy Economics* **29** (4), 913–933.

Shan, B.— G., Xu, M.— J., Zhu, F.— G., & Zhang, C.— L. (2012), "China's Energy Demand Scenario Analysis in 2030", *Energy Procedia* **14,** 1292–1298.

Tao, Z., Zhao, L., & Changxin, Z. (2011), "Research on the prospects of low-carbon economic development in China based on LEAP model", *Energy Procedia* **5,** 695–699.

Zhang, L., Feng, Y., & Chen, B. (2011), "Alternative Scenarios for the Development of a Low-Carbon City: A Case Study of Beijing, China", *Energies* **4** (12), 2295–2310.

Study of Government Policies for Promotion of Green Technology in the Framework of Real Business Cycle Model*

Elena STEPANOVA
Santa Anna School of Advanced Studies, Pisa, Italy
e.stepanova@sssup.it

Abstract. This paper analyzes possible impact of government reduction in market entry costs for firms that are using green technologies. Government may promote use of green technologies by facilitating market entry for such companies. Or government may impose restrictions to enter the market if firms are not using the green technology, which will result in increase of sunk costs of entering the market. We study cases of reduction and increase in market entry costs using Real Business Cycle model (RBC) with endogenous entry and different forms of market competition. We compare impact from supply shock in the form of reduction (or increase) in entry costs to standard form of supply shock, i. e. improvement in technology.

Аннотация. Статья рассматривает влияние государственной политики снижения затрат на вход на рынок для фирм, использующих зеленые технологии. Государство может стимулировать использование зеленых технологий, упрощая возможности входа на рынок для таких компаний. Государство также может наложить запреты и ограничения на вход в отрасль, если фирма не использует зеленые технологии, что вызовет рост необходимых капиталовложений для входа на рынок. Мы изучаем случаи уменьшения и увеличения необходимых капиталовложений для входа на рынок, используя модель реального бизнес-цикла с эндогенным входом фирм на рынок и различными формами конкуренции. Мы сравниваем влияние шока-предложения, а именно уменьшения (увеличения) необходимых капиталовложений для входа на рынок, и стандартного шока-предложения, а именно улучшения технологий производства.

Key words: Real Business Cycle, endogenous entry.

INTRODUCTION

It is reasonable to study the problem of facilitating market access for green technology firms in the framework of RBC models with endogenous number of producers. These models were proposed in Ghironi and Melitz (2005), Bilbiie, Ghironi and Melitz (BGM, 2007) and Etro (2009). Moreover, as we want to see impact of market competition on business cycle properties of the model, we impose imperfect competition, as it is done in Etro and Colciago (EC, 2010) and Colciago and Etro (2010). In this manner the model departs from the RBC model assumption of homogenous goods and considers goods that can be imperfectly substitutable. We will not focus on the general equilibrium properties of the model as they are extensively studied in the above-mentioned literature. What we aim to show in the paper are possible consequences for the economy business cycle of government's efforts to facilitate market entry for green technology firms, or to restrict access to the market for firms that are not using green technologies. In BGM (2008) it was shown that in RBC model with endogenous entry government subsidy to firm entry financed by lump-sum taxes on profits is optimal in a sense that economy first best allocation is reached. Here we will study the case of government lowering entry barriers to the firms. This can be done also in the form of subsidies, which will bring us close to BGM (2008) case. The policy can be applied when government wants to promote use of green technologies by facilitating access to the market for such firms, and we want to study economic consequences of such policy. The model also allows to study the opposite policy, when the government forbids market entry if the firm is not using green technology, which will increase sunk costs of entry to the market, and we are interested in impact of such policy on the whole economy.

The paper is organized as follows. In the first section we introduce notions and explain the model dynamics. In the second section we study transmission of economic fluctuations due to shock to the entry cost by means of computing impulse response functions. We perform comparison between classical supply shock

* Изучение государственной политики стимулирования зеленых технологий в рамках модели реального бизнес-цикла

and entry cost shock. We are interested in economic implications of government policy aimed to support and protection of green technology companies. Last section provides some conclusions and possible directions for further research.

1 MODEL SETUP

1.1 HOUSEHOLD PREFERENCES

The number of households in the economy is normalized to unity. Let us assume that contracts and prices are indicated in nominal terms with prices being flexible. Thus, it is sufficient to solve model only for real variables. Money does not have any role in the economy; it is introduced only as convenient unit of account for contracts. Composition of the consumption basket changes over time due to firm entry affecting the definition of the consumption-based price index.

The representative household supplies L units of labor inelastically in each period at the nominal wage rate W_t. The household maximizes expected intertemporal utility from consumption (C):

$$E_t\left(\sum_{s=t}^{\infty}\beta^{s-t}U\left(C_s\right)\right),$$

where $\beta\in\left(0,1\right)$ is the subjective discount factor and $U\left(C\right)$ is a period utility function with the standard properties. At time t, the household consumes the basket of goods C_t, defined over a continuum of goods Ω. At any given time t, only a subset of goods $\Omega_t\subset\Omega$ is available.

Let $p_t\left(\omega\right)$ denote the nominal price of a good $\omega\in\Omega_t$.

For any symmetric homothetic preferences, there exists a well-defined consumption index C_t and an associated welfare-based price index P_t.

The demand for an individual variety, $c_t\left(\omega\right)$, is then defined as

$$c_t\left(\omega\right)d\omega=C_t\frac{\partial P_t}{\partial p_t\left(\omega\right)},$$

where, by the conventional notation, quantities with a continuum of goods are flow values.

The relative price ρ describes the benefit of additional product variety:

$$\rho_t\left(\omega\right)=\rho\left(N_t\right)\equiv\frac{p_t\left(\omega\right)}{P_t}\text{, for any symmetric variety }\omega, \tag{1.1}$$

or, in elasticity form it is expresses as:

$$\varepsilon\left(N_t\right)\equiv\frac{\rho'\left(N_t\right)}{\rho\left(N_t\right)}N_t,$$

where N_t is the number of producers.

The model considers C.E.S. preferences (constant elasticity of substitution between goods) as initially proposed in Dixit and Stiglitz (1977). Therefore the consumption aggregator is

$$C_t=\left(\int_{\omega\in\Omega}c_t\left(\omega\right)^{\theta-1/\theta}d\omega\right)^{\frac{\theta}{\theta-1}}$$

where $\theta>1$ is the symmetric elasticity of substitution across goods or we will also call it the degree of substitutability between goods.

The consumption-based price index is then

$$P_t=\left(\int_{\omega\in\Omega_t}p_t\left(\omega\right)^{1-\theta}d\omega\right)^{\frac{1}{1-\theta}} \tag{1.2}$$

and the household's demand for each individual good ω is

$$c_t(\omega) = C_t\left(\frac{p_t(\omega)}{P_t}\right)^{-\theta}. \tag{1.3}$$

Proof of 1.3

Let us denote expenditure in each sector of economy as $EXP_t = C_t P_t$

In each time period the households maximize consumption in this time period by choosing bundle of goods ω under the time period budget constraint. Demand for each individual good is delivered by solution of the following optimization problem:

$$\begin{cases} \max\limits_{\{c_t(\omega)\}} \quad C_t \\ \textit{subject to} \int\limits_{\omega\in\Omega} p_t(\omega)c_t(\omega)d\omega = EXP_t \end{cases}$$

Lagrangian for this problem is: $L = \left(\int\limits_{\omega\in\Omega} c_t(\omega)^{\theta-1/\theta} d\omega\right)^{\frac{\theta}{\theta-1}} - \lambda\left(\int\limits_{\omega\in\Omega} p_t(\omega)c_t(\omega)d\omega - EXP_t\right)$

First order conditions with respect to $c_t(\omega)$: $\frac{\theta}{\theta-1}\left(\int\limits_{\omega\in\Omega} c_t(\omega)^{\theta-1/\theta} d\omega\right)^{\frac{1}{\theta-1}} \frac{\theta-1}{\theta} c_t(\omega)^{\frac{-1}{\theta}} = \lambda p_t(\omega)$

$$c_t(\omega)^{\frac{-1}{\theta}} = \lambda p_t(\omega)\left(\int\limits_{\omega\in\Omega} c_t(\omega)^{\theta-1/\theta} d\omega\right)^{\frac{-1}{\theta-1}}$$

$$c_t(\omega) = \lambda^{-\theta} p_t(\omega)^{-\theta} C_t \tag{1.3.1}$$

First order conditions with respect to λ: $\int\limits_{\omega\in\Omega} p_t(\omega)c_t(\omega)d\omega = EXP_t$, where we plug (1.3.1) and get

$\int\limits_{\omega\in\Omega} p_t(\omega)\lambda^{-\theta} p_t(\omega)^{-\theta} C_t d\omega = EXP_t$, then we used formula for expenditure and get $\lambda^{-\theta} C_t \int\limits_{\omega\in\Omega} p_t(\omega)^{1-\theta} d\omega = P_t C_t$; or after simplification $\lambda^{-\theta} \int\limits_{\omega\in\Omega} p_t(\omega)^{1-\theta} d\omega = P_t$

here we use formula of the price index (1.2) $P_t = \left(\int\limits_{\omega\in\Omega_t} p_t(\omega)^{1-\theta} d\omega\right)^{\frac{1}{1-\theta}}$ and we get that:

$$\lambda^{-\theta} \int\limits_{\omega\in\Omega} p_t(\omega)^{1-\theta} d\omega = \left(\int\limits_{\omega\in\Omega_t} p_t(\omega)^{1-\theta} d\omega\right)^{\frac{1}{1-\theta}}$$

$$\lambda = \left(\int\limits_{\omega\in\Omega_t} p_t(\omega)^{1-\theta} d\omega\right)^{\frac{-1}{1-\theta}} = \frac{1}{P_t}$$

Plugging λ back to (1.3.1) we get the result $c_t(\omega) = C_t\left(\frac{p_t(\omega)}{P_t}\right)^{-\theta}$

1.2 FIRMS

The economy is populated by a continuum of firms, each producing a different variety/good $\omega \in \Omega$. For simplicity, the model equates a producer with a production line for an individual variety/good (while empirically, a firm may comprise more than one production line). Model does not address the determination of product variety within firms. So process of producer entry and exit should be seen in broad sense, i. e. as also incorporating product creation and destruction by existing firms within them.

Production depends on only one factor, which is labor. Aggregate labor productivity is indexed by A_t, which represents the effectiveness of one unit of labor. A_t is exogenous variable of the model. Output supplied by firm ω is

$$y_t(\omega) = A_t l_t(\omega),$$

where $l_t(\omega)$ denotes the firm's labor demand for production purpose. The unit cost of production, in units of the consumption good C_t, is $\frac{w_t}{A_t}$, where $w_t \equiv \frac{W_t}{P_t}$ is the real wage.

Prior to entry, firms face a sunk entry cost of $\eta_{E,t}$ effective labor units, equal to $\eta_{E,t}\frac{w_t}{A_t}$ units of the consumption basket. $\eta_{E,t}$ is exogenous variable of the model. Given model assumption that each firm can be seen as a production line for a good, the entry cost can, in turn, be seen as the development and setup cost associated with a good (potentially influenced by market regulation). Producer does not face any fixed costs.

All firms that enter the economy produce in every period, until they are hit with a "death" shock, which occurs with probability $\delta \in (0,1)$ in every period. The exogenous "death" shock also takes place at the individual variety level.

Firms set prices in a flexible fashion as markups over marginal costs. In units of consumption, firm ω's price is

$$\rho_t(\omega) = \mu_t \frac{w_t}{A_t},$$

where μ_t stands for the markup. The firm's profit in units of consumption is

$$d_t(\omega) = \left(1 - \frac{1}{\mu(N_t)}\right)\frac{Y_t^C}{N_t}, \tag{1.4}$$

where Y_t^C is total output of the consumption basket and will in equilibrium be equal to total consumption demand C_t.

We denote firm's profits with d_t having in mind that all firm's profits are paid out as dividends.

1.3 SYMMETRIC FIRM EQUILIBRIUM

All firms face the same marginal cost. Hence, equilibrium prices, quantities, and firm profits and values are identical across firms: $p_t(\omega) = p_t$, $\rho_t(\omega) = \rho_t$, $l_t(\omega) = l_t$, $y_t(\omega) = y_t$, $d_t(\omega) = d_t$, $\upsilon_t(\omega) = \upsilon_t$.

In turn, equality of prices across firms implies that the consumption-based price index P_t and the firm-level price p_t are such that the following is fulfilled $\frac{p_t}{P_t} \equiv \rho_t = \rho(N_t)$.

Therefore benefit of additional product variety is described by:

$$\rho(N_t) \equiv \frac{p_t}{P_t} = \frac{p_t}{\left(\int_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}} = \frac{p_t}{N^{\frac{1}{1-\theta}} \left(p_t^{\,1-\theta} \right)^{\frac{1}{1-\theta}}} = N^{\frac{1}{\theta-1}}$$

An increase in the number of firms necessarily implies that the relative price of each individual good increases because $\rho'(N_t) > 0$. When there are more firms, households derive more welfare from spending a given nominal amount, i. e., *ceteris paribus*, the price index decreases. It follows that the relative price of each individual good must rise.

The aggregate consumption output of the economy is

$$Y_t^C = N_t \rho_t y_t = C_t$$

Importantly, in the symmetric firm equilibrium, the value of waiting to enter is zero, despite the entry decision being subject to sunk costs and exit risk; i. e., there are no option-value considerations pertaining to the entry decision. This happens because all uncertainty in the model (including the "death" shock) is aggregate.

1.3.1 EQUILIBRIUM UNDER MONOPOLISTIC COMPETITION

Given household's demand for each individual good $c_t(\omega)$ (1.3) profits of a firm at time t are:

$$d_t(\omega) = \left(p_t(\omega) - cost_t\right) c_t(\omega) = \left(p_t(\omega) - cost_t\right) C_t \left(\frac{p_t(\omega)}{P_t} \right)^{-\theta} \quad (1.5)$$

where $cost_t$ is the (nominal) marginal cost of production.

Let us now assume that there is infinity of monopolistic firms, each one acts independently in the choice of its price in every period, and has no impact on the price index or the consumption index. Accordingly, from the first order conditions the profit-maximizing price is

$$p_t = \frac{\theta}{\theta - 1} cost_t$$

for each firm, which corresponds to a common and constant markup for all goods:

$$\mu(N_t) = \mu = \frac{\theta}{\theta - 1}$$

1.3.2 EQUILIBRIUM UNDER BERTRAND COMPETITION

Let us denote expenditure in each sector of economy as $EXP_t = C_t P_t$, then household's demand for each individual good $c_t(\omega)$ (1.3) can be re-written as $c_t(\omega) = EXP_t \frac{p_t(\omega)^{-\theta}}{P_t^{1-\theta}}$. Using expression for price index P_t (1.2) we get that profit of a firm (1.5) is:

$$d_t(\omega) = \left(p_t(\omega) - cost_t\right) c_t(\omega) = \left(p_t(\omega) - cost_t\right) EXP_t \frac{p_t(\omega)^{-\theta}}{\int_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega}$$

Under competition in prices we derive Bertrand equilibrium price as price that maximizes firms' profit taking as given the prices of the other firms and expenditure in each sector. First order conditions of the profit maximization problem are:

$$\left\{p_t(\omega)^{-\theta} - \theta\left(p_t(\omega) - cost_t\right)p_t(\omega)^{-\theta-1}\right\} = \frac{(1-\theta)\,p_t(\omega)^{-\theta}\left(p_t(\omega) - cost_t\right)p_t(\omega)^{-\theta}}{\int_{\omega\in\Omega_t} p_t(\omega)^{1-\theta}\,d\omega}$$

Using the fact that equilibrium is symmetric we can replace $\int_{\omega\in\Omega_t} p_t(\omega)^{1-\theta}\,d\omega = N_t p_t^{1-\theta}$. And solving for p_t we get:

$p_t = \frac{\theta(N_t - 1) + 1}{(N_t - 1)(\theta - 1)} cost_t$ for each firm,

which corresponds to markup of:

$$\mu(N_t) = \frac{\theta(N_t - 1) + 1}{(N_t - 1)(\theta - 1)}$$

1.3.3 EQUILIBRIUM UNDER COURNOT COMPETITION

Given household's demand for each individual good $c_t(\omega)$ (1.3) and using that in equilibrium demand equals supply — $y_t(\omega)$ inverse demand function will be:

$$p_t(\omega) = \frac{y_t(\omega)^{-\frac{1}{\theta}}}{\int_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}}\,d\omega} EXP_t\ ,$$

where expenditure in each sector of economy are $EXP_t = C_t P_t$. We get that profit of a firm (1.5):

$$d_t(\omega) = \left(p_t(\omega) - cost_t\right)y_t(\omega) = \left(\frac{y_t(\omega)^{-\frac{1}{\theta}}}{\int_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}}\,d\omega} EXP_t - cost_t\right) y_t(\omega)$$

Under competition in quantities each firm chooses $y_t(\omega)$ that maximizes profits taking as given supply of other firms. First order conditions of the profit maximization problem are:

$$\left(\frac{\theta-1}{\theta}\right)\frac{y_t(\omega)^{-\frac{1}{\theta}}}{\int_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}}\,d\omega} EXP_t - \left(\frac{\theta-1}{\theta}\right)\frac{y_t(\omega)^{\frac{\theta-2}{\theta}}}{\left(\int_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}}\,d\omega\right)^2} EXP_t = cost_t$$

Using the fact that equilibrium is symmetric we can replace $\int_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}}\,d\omega = N_t y_t^{\frac{\theta-1}{\theta}}$. And solving for y_t we obtain: $y_t = \frac{(\theta-1)(N_t-1)}{\theta N_t^2 cost_t} EXP_t$. Substituting back into inverse demand function, we get the equilibrium price:

$$p_t = \frac{\theta N_t}{(\theta - 1)(N_t - 1)} cost_t$$ for each firm,

which corresponds to markup for all goods:

$$\mu(N_t) = \frac{\theta N_t}{(N_t - 1)(\theta - 1)}$$

1.4 FIRM ENTRY AND EXIT

In each period there are N_t firms in economy and unlimited number of potential new entrants. Potential new entrants are forward-looking, and foresee their excepted profits $d_s(\omega)$ in every future period $s \geq t+1$ as well as the probability δ (in every period) of incurring the exogenous "death" shock. Entrants at time t only start producing at time $t+1$, which introduces one-period time-to-build lag in the model. The exogenous exit shock occurs at the very end of the time period (after production and entry). A proportion δ of new entrants will therefore never produce. Prospective entrants in period t compute their expected post-entry value ($\upsilon_t(\omega)$) given by the present discounted value of their expected stream of profits $\{d_s(\omega)\}_{s=t+1}^{\infty}$:

$$\upsilon_t(\omega) = E_t\left(\sum_{s=t+1}^{\infty} \left[\beta(1-\delta)\right]^{s-t} \frac{U'(C_s)}{U'(C_t)} d_s(\omega)\right) \tag{1.6}$$

This also represents the value of incumbent firms after production has occurred (since both new entrants and incumbents then face the same probability $1-\delta$ of survival and production in the subsequent period). Entry occurs until firm value is equalized with the entry cost, leading to the free entry condition

$$\upsilon_t(\omega) = w_t \frac{\eta_{E,t}}{A_t}. \tag{1.7}$$

The condition holds as long as the number $N_{E,t}$ of new entrants is positive. It is assumed that macroeconomic shocks are small enough for this condition to hold in every period.

Finally, the timing of entry and production assumptions imply that the number of producing firms in period t is given by

$$N_t = (1-\delta)(N_{t-1} + N_{E,t-1}). \tag{1.8}$$

The number of producing firms represents the capital stock of the economy. It is an endogenous state variable that behaves much like physical capital in the benchmark RBC model.

1.5 HOUSEHOLD BUDGET CONSTRAINT AND INTERTEMPORAL DECISIONS

Without loss of generality let us assume that households hold only shares in a mutual fund of firms.

Let x_t be the share in the mutual fund of firms held by the representative household entering period t. The mutual fund pays a total profit in each period (in units of currency) equal to the total profit of all firms that produce in that period, $P_t N_t d_t$. During period t, the representative household buys x_{t+1} shares in a mutual fund of $N_{H,t} \equiv N_t + N_{E,t}$ firms (those already operating at time t and the new entrants). Only $N_{t+1} = (1-\delta) N_{H,t}$ firms will produce and pay dividends at time $t+1$. Since the household does not know which firms will be hit by the exogenous exit shock δ at the very end of period t, it finances the continuing operation of all pre-existing firms and all new entrants during period t. The date t price (in units of currency) of a claim to the future profit stream of the mutual fund of $N_{H,t}$ firms is equal to the nominal price of claims to future firm profits, $P_t \upsilon_t$.

The household enters period t holding x_t of mutual fund shares, it receives dividend income, the value of selling its initial share position, and income from supplying labor. The household allocates these resources between purchases of x_{t+1} shares to be carried into next period, consumption C_t. So in each period household budget constraint (in units of consumption) is of the form:

$$\upsilon_t N_{H,t} x_{t+1} + C_t = (d_t + \upsilon_t) N_t x_t + w_t L \tag{1.9}$$

The household maximizes its expected intertemporal utility subject to (1.9). The Euler equation for share holdings is:

$$\upsilon_t = \beta(1-\delta) E_t \left(\frac{U'(C_{t+1})}{U'(C_t)} (d_{t+1} + \upsilon_{t+1}) \right) \tag{1.10}$$

As expected, forward iteration of this equation and absence of speculative bubbles yield the asset price solution in equation (1.6).

1.6 AGGREGATE ACCOUNTING AND EQUILIBRIUM

Summing up individual budget constraints of households (1.9) across all the economy and imposing the equilibrium condition $x_{t+1} = x_t = 1 \ \forall t$ we obtain the aggregate accounting identity that should be fulfilled in each period:

$$C_t + N_{E,t} \upsilon_t = w_t L + N_t d_t : \tag{1.11}$$

Total consumption plus investment (in new entrants) must be equal to total income (part of which is coming from supplying labor and the other — from return on investments in the form of dividends).

As opposed to RBC model, in the current model we need to distinguish between labor that is used in production of consumption goods and labor employed in setting-up new firms (increasing capital stock of the economy). So current model can be viewed as a two-sector economy. While in the benchmark RBC model, capital stock is accumulated by using as investment part of the output of the same good used for consumption and all labor is allocated only to the productive sector of the economy.

The total output of the economy, Y_t, is equal to total income, $w_t L + N_t d_t$. On the other side, Y_t is also given by consumption output, $Y_t^C (= C_t)$, plus investment output, $N_{E,t} \upsilon_t$. We also note that, firm value υ_t can be viewed as the relative price of the investment "good" in terms of consumption.

Equilibrium on the labor market requires that the sum of amount of labor used in production of consumption goods L_t^C and amount of labor employed in setting-up the new entrants' plants L_t^E must equal aggregate labor supply:

$$L_t^C + L_t^E = L,$$

where the amount of labor used in production of consumption can be expressed as $L_t^C = N_t l_t$, and the amount of labor used to build new firms can be expressed as $L_t^E = N_{E,t} \frac{\eta_{E,t}}{A_t}$.

When labor supply is fixed, there are no labor market dynamics in the model, other than the determination of the equilibrium wage along a vertical supply curve. In the model, even when labor supply is fixed, labor market dynamics arise in the allocation of labor between production of consumption and creation of new firms. The allocation is determined jointly by the entry decision of prospective entrants and the portfolio decision of households who finance that entry. The value of firms, or as we also call it the relative price of investment in terms of consumption υ_t, plays a crucial role in determining this allocation. (When labor supply is elastic, labor market dynamics operate along two margins as the interaction of household and firm decisions determine jointly the total amount of labor and its allocation to the two sectors of the economy.)

Uniqueness and stability of the model equilibrium is guided by the choice of the utility function. Here following BGM (2007) we assume that utility function is of the form:

$$U(C_t, L_t) = \ln C_t - \chi (L_t)^{1+\frac{1}{\phi}} \Big/ 1 + \frac{1}{\phi}, \tag{1.21}$$

where $\chi > 0$ and $\phi > 0$ is Frish elasticity of labor supply to wages, and intertemporal elasticity or substitution in labor supply. The choice of utility function of this particular form was guided by results in King, Plosser, and Rebelo (1988): Given separable preferences, log utility from consumption ensures that income and substitution effects of real wage variation on effort cancel out in steady state; this is necessary to have constant steady-state effort and balanced growth if there is productivity growth. BGM (2007) provides also the proof that the steady state will be non-explosive. E. Stepanova (2011) analyses differences in steady states under different forms of market competition.

2 MODEL DYNAMICS — PROPAGATION OF SHOCKS

In this section we study transmission of economic fluctuations due to shock to the entry cost by means of computing impulse response functions. We perform comparison between classical supply shock (productivity shock) and entry cost shock. We are interested in economic implications of government policy aimed to support and protect green technology companies.

The model allows for a large variety of combinations of substitutability between goods (θ) and markup (μ), which in turn depends on the form of competition. We consider cases of Cournot, Bertrand and monopolistic competition discussed in section 1.3.

Calibration of structural parameters is standard and follows King and Rebelo (1999). The time unit is a quarter. The discount factor, β, is 0.99, while the rate of business destruction, δ, equals 0.025 implying an annual rate of 10%. The Frish elasticity of labor supply is ϕ, and we fix it at 4 as in King and Rebelo (1999).

Government spending is financed by lump sum tax and is 20% of total output of the economy, replicating the real world economy.

2.1 DIFFERENCES IN RESPONSE TO A PRODUCTIVITY SHOCK AND A SUNK ENTRY COST SHOCK

A shock of 1% increase in productivity decreases marginal cost of production and respectively causes markups decrease. A shock of 1% increase in sunk entry costs augments up-front investments and respectively causes markups increase. Keep in mind that we assume, for example, government policy of obligatory use of green technologies if a company wants to enter the market. Of course, this creates additional pre-production investments into green technologies and increases sunk costs of firm entry to the market. High entry cost compared to the size of the market leads to a smaller number of competitors and thus to higher markups. As consequence of markups moving in contrary directions for these two types of shocks, all other variables also respond contrarily. We may say that productivity shock is a positive one, while sunk entry cost shock is a negative one. To correct this and keep the same direction of variable responses for both shocks we will consider a shock of 1% decrease in sunk entry costs, and will compare it to a shock of 1% increase in productivity. Keep in mind that decrease in sunk entry costs corresponds to government subsidizing use of green technology.

In case of the productivity shock we set the steady state productivity value to A = 1 and the baseline value for the entry cost is set to η = 1. Shock to the model technology parameter follows the first order autoregressive process: $A_t = \varphi_A A_{t-1} + \varepsilon_{A,t}$ where hat above the variable means percent deviation from steady state level for this variable, $\varphi_A \in (0,1)$ is the autocorrelation coefficient, and $\varepsilon_{A,t}$ is a white noise disturbance, with zero expected value and standard deviation $\sigma^2_{\varepsilon_A}$.

In case of the sunk entry cost shock we set the steady state entry cost value to η = 1 and the baseline value for productivity to A = 1. Shock to the sunk entry cost parameter follows the first order autoregressive process: $\left(\frac{1}{\eta}\right)_t = \varphi_\eta \left(\frac{1}{\eta}\right)_{t-1} + \varepsilon_{\eta,t}$ where hat above the variable means percent deviation from steady state level for this variable, $\varphi_\eta \in (0,1)$ is the autocorrelation coefficient, and $\varepsilon_{\eta,t}$ is a white noise disturbance, with zero expected value and standard deviation $\sigma^2_{\varepsilon_\eta}$.

Figure 1 depicts percentage deviations from the steady state of key variables in response to a 1% productivity shock and sunk entry cost shock with persistency $\varphi_A = \varphi_\eta = 0,9$. We simulate for the case of Cournot competition and the degree of substitutability is 6 ($\theta = 6$). Time on the horizontal axis is in quarters.

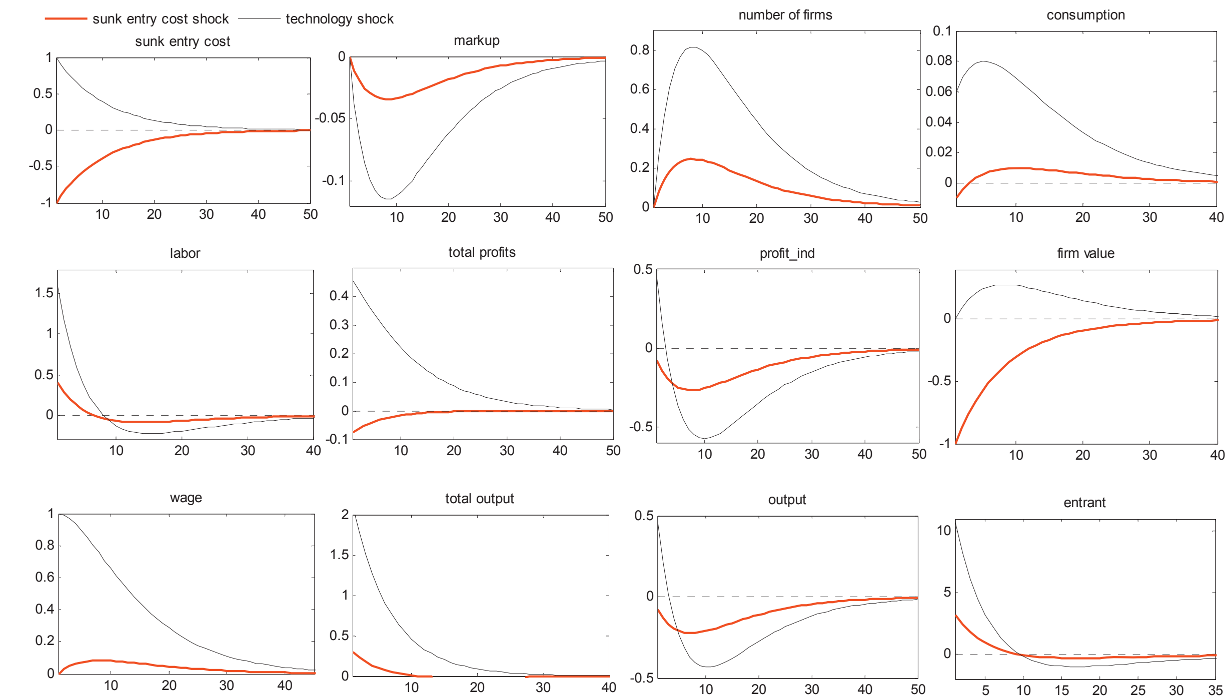


Figure 1. Decrease in sunk cost of entry shock vs production shock ($\theta = 6$) – impulse response functions (IRF).

We see that the productivity shock has a stronger effect in terms of deviation from the steady state. Response of the markup and the number of firms to the productivity shock is more than double in comparison with the sunk entry cost shock. Explanation of this is the fact that the productivity shock initially impacts a bigger number of firms (i. e., all firms that are on the market at the moment of the shock), while decrease in the entry cost initially impacts a smaller number of firms — only "new entrant firms". So the propagation of a productivity shock happens with a higher strength.

We further proceed with the comparison of variables response to both shocks. In advance we need to say that even if directions of convergence back to the steady state are the same, the incentives to this behavior are different.

First, we explain our intuition for the variables response to the sunk entry cost shock. The number of entrants increases, it strengthens market competition and reduces the markups. A reduction in the markup means a reduction in profits and, consequently, in the firms' value, as it is discounted sum of future profits. The consumption initially decreases as households decide to postpone it in favor of investments and the entrance to the market by investing into creation of new firms. The firms' value is very cheap. At the same time households feel poorer due to reduction in profits as it is a source of their income, and no changes in their wages as another source of their income, so they increase labor supply.

An increase in the total number of firms leads to increase in labor demand from the firms' side and this pushes up wages. Thus households reduce labor supply. At the same time as the total profits and the firms' value grow households feel richer and increase their consumption. They start decreasing investments as creation of new firms becomes more expensive due to the wages increase.

Table 1. Differences in response to a productivity shock and a sunk entry cost shock.

Variable	**Initial response**		**Behavior along the transition path**	
	A **shock**	η **shock**	A **shock**	η **shock**
consumption	+	–		
individual profit	+	–	Decreases	Increases
wage	+	No reaction	Decreases	Hump shaped that starts from increase
output	+	–		
firm value	No reaction	–	Hump shaped that starts from increase	Increases

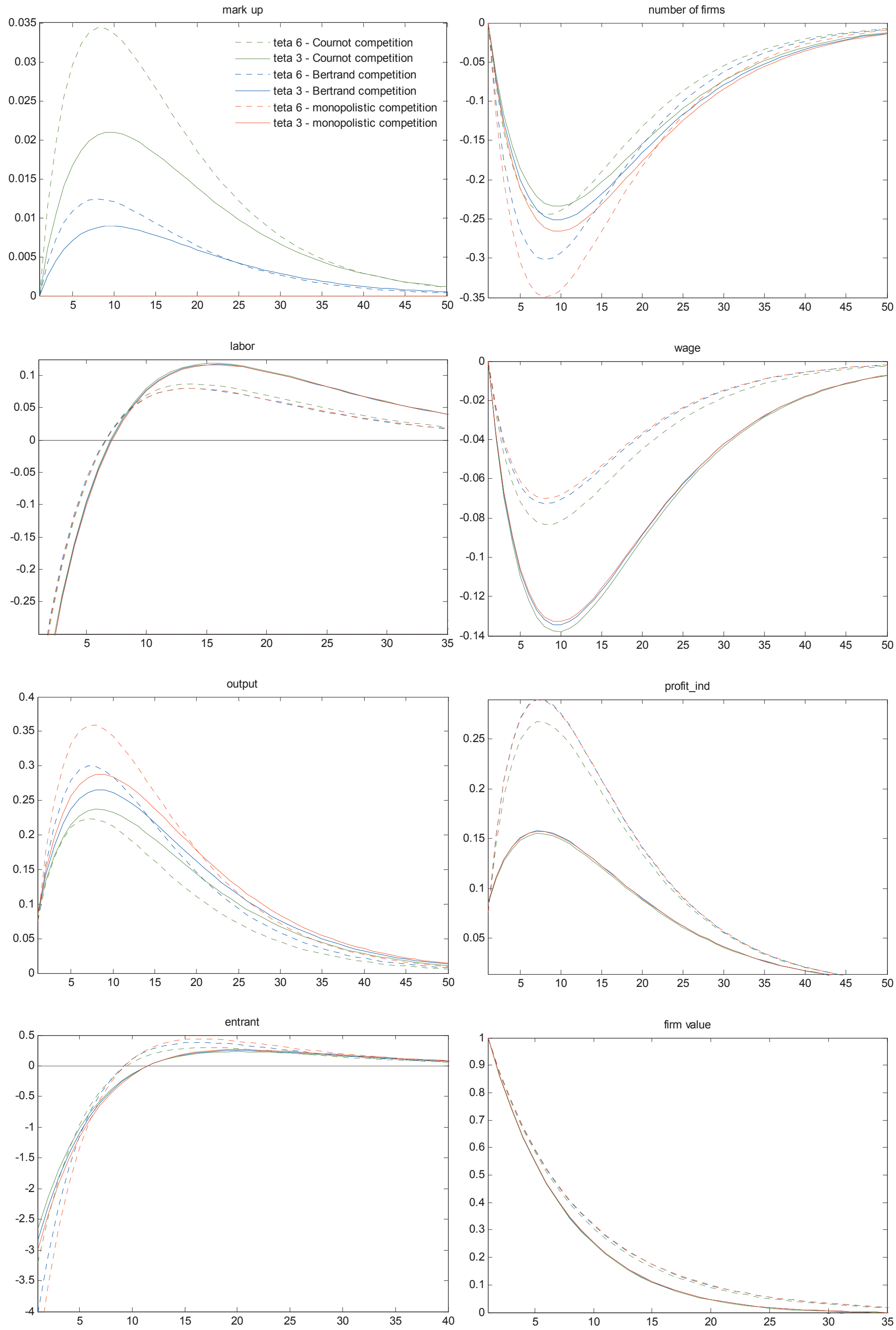


Figure 2. Increase in sunk cost of entry shock – comparison of different forms of competition ($\theta = 6$, $\theta = 3$) – IRF.

At some point the variable "the number of new entrants" crosses its steady state level. It happens at the same time for the both shocks. At this point the total number of firms reaches their maximum and the markup — their minimum level. From this moment net exit from the market starts. This makes the markup start increasing towards the steady state level. Individual profits as well as individual output start increasing. Wages start decreasing with decreasing labor demand from the firms' side. Labor supply increases in response.

As shocks vanish variables converge to initial steady state levels.

The Table 1 summarizes main differences in the variables behavior for both shocks.

The explanation for these differences is the dissimilar incentives driving the variables reaction. Contrary to a sunk entry cost shock productivity shock increases individual output and profits on impact. There is a big

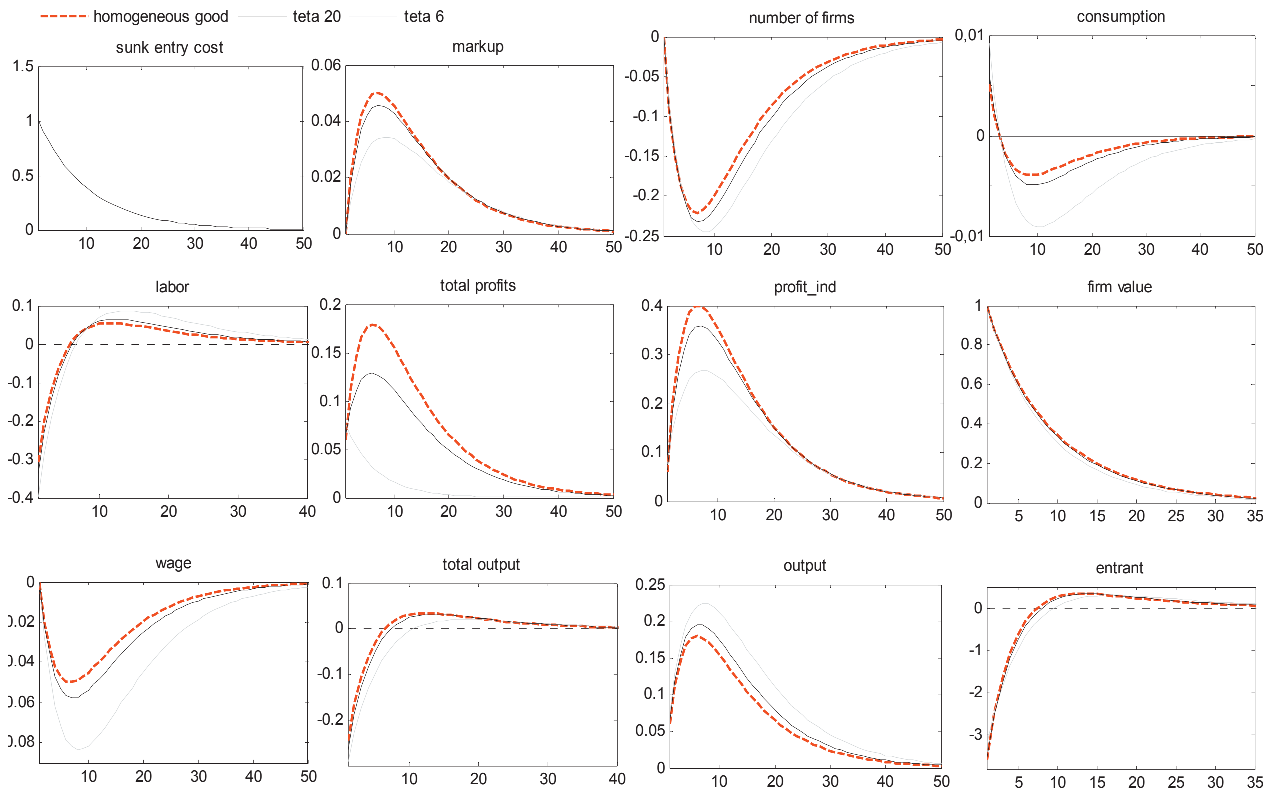


Figure 3. Increase in sunk cost of entry shock – Cournot competition ($\theta = 6$, $\theta = 20$, $\theta = \infty$) – IRF.

demand for labor as production is profitable, that is why wages are initially pushed up. As there are more profits in the economy and also wages are high households feel rich — so they have a higher consumption level than in the steady state. The firms' value being equal to the cost of entry $\upsilon_t(\omega) = w_t \frac{\eta_{E,t}}{A_t}$ doesn't change as two effects — increase in labor productivity and increase in labor cost — cancel each other out.

2.2 RESPONSE TO A SHOCK UNDER DIFFERENT TYPES OF COMPETITION

It is important to outline the difference between variables responses in case of different markup types, i. e. different forms of competition. On Figure 2 we report impulse response functions for a temporary shock of 1% increase in sunk entry cost. We consider degree of substitutability θ of 6 and 3 ($\theta = 6$, $\theta = 3$) and we consider three forms of competition (in quantities — in green, in prices — in blue and monopolistic — in red).

First we report difference in the variables steady state values. Under competition in prices and in quantities (for $\theta = 6$) the market structure is generated endogenously and the steady state markups are respectively 23,7% and 36,8%, both belonging to the empirically reasonable range, for the monopolistic competition markup is 20% and is constant. When firms compete in prices the equilibrium markups are lower, which in turn allows for a lower number of firms to be active in the market: this implies that the model is characterized by a lower number of goods compared to the model with competition in quantities. Since this requires a smaller number of new firms to be created in the steady state, lower markups are associated with a lower saving rate as well.

In spite of these substantial differences in the steady state of the economy, Figure 2 shows that the quantitative reaction of the main aggregate variables to the shock are similar under all forms of competition. The impact of the shock is strengthened by competition effect. Along the transition path we see how new firms' entry starts reduction of markups by strengthening market competition. But we cannot unambiguously conclude which type of competition creates stronger response to the shock as it differs from variable to variable and also with degree of substitutability.

2.3 RESPONSE TO A SHOCK UNDER DIFFERENT DEGREE OF SUBSTITUTABILITY

When we increase the degree of substitutability (for example as we pass from $\theta = 6$ to $\theta = 20$ and $\theta = \infty$ – case of homogeneous good) the same qualitative results hold, but the impact of the shock on competition and mark ups becomes stronger.

We depict this situation on Figure 3 for the case of Cournot competition.

The noticeable difference is the total profits decrease along all transition path in case of low degree of substitutability, while total profits are hump-shaped in case of high degree of substitutability. This can be explained by significant decrease in the number of firms in case of low substitutability so that individual profits generated by firms are not enough to make total profits grow.

CONCLUSIONS

We see that government intervention aiming to promote use of green technologies by restricting market access to firms that are not having them reduces the number of firms on the market, increases their profits and motivation to produce more. Government subsidizing entry for firms using green technologies have the opposite influence on economy: we see strengthening of competition, decrease in markups and reduction of profits. We studied the effect of different forms of competition and different degrees of products substitutability. The model can be based on real country economy's data, which will give the country's government real figures to measure impact of its green technology policies.

Further research directions are the following: within current model framework it will be interesting to see the impact of different taxation schemes. In the model government spending is financed by the lump-sum tax, while it would be more realistic to consider different forms of financing of government spending. It will be also interesting to study the same problem in the framework of agent-based model, where one can allow for differences across firms in their productivity based on whether they are or are not using green technology.

REFERENCES

Bilbiie F. O., Ghironi F. and Melitz M. J. (2007), "Endogenous Entry, Product Variety, and Business Cycles", National Bureau of Economic Research, Working Paper 13646.

Bilbiie F. O., Ghironi F. and Melitz M. J. (2008), "Monopoly Power and Endogenous Product Variety: Distortions and Remedies", National Bureau of Economic Research, Working Paper 14383.

Blanchard, O. and Kiyotaki, N. (1987), "Monopolistic Competition and the Effects of Aggregate Demand", *American Economic Review* **77** (4), 647–666.

Bresnahan, T. and Reiss, P. (1987), "Do Entry Conditions Vary Across Markets?", *Brookings Papers on Economic Activity* **3**, 833–881.

Campbell, J. and Hopenhayn, H. (2005), "Market Size Matters", *Journal of Industrial Economics* **53** (1), 1–25.

Campbell, J. Y. (1994), "Inspecting the Mechanism: An Analytical Approach to the Stochastic Growth Model", *Journal of Monetary Economics* **33**, 463–506.

Colciago, A. and Etro, F. (2010), "Real Business Cycles with Cournot Competition and Endogenous Entry", *Journal of Macroeconomics* **32** (4), 1101–1117.

Dixit, A.K. and Stiglitz, J.E. (1977), "Monopolistic Competition and Optimum Product Diversity", *American Economic Review* **67**, 297–308.

Etro, F. (2009), *Endogenous Market Structures and the Macroeconomy*, New York and Berlin: Springer.

Etro, F. and Colciago, A. (2010), "Endogenous Market Structures and the Business Cycle", *The Economic Journal* **120** (549), 1201–1234.

Ghironi, F. and Melitz, M. (2005), "International Trade and Macroeconomic Dynamics with Heterogenous Firms", *Quarterly Journal of Economics* **CXX**, 865–915.

King, R. G. and Rebelo, S. T. (1999), "Resuscitating Real Business Cycles", in Taylor, J. B., & M. Woodford, eds., *Handbook of Macroeconomics*, vol. 1B, Amsterdam: Elsevier, pp. 927–1007.

Kydland, F. and Prescott, Ed. (1982), "Time to Build and Aggregate Fluctuations", *Econometrica* **s50** (6), 1345–1370.

Manuszak, M. and Moul, Ch. (2008), "Prices and Endogenous Market Structure in Office Supply Superstores", *Journal of Industrial Economics* **56**, 94–112.

Manuszak, M. (2002), "Endogenous Market Structure and Competition in the 19th Century American Brewing Industry", *International Journal of Industrial Organization* **20**, 673–932.

Robinson, J. (1933), *The Economics of Imperfect Competition*, Cambridge, UK: Cambridge University Press.

Stepanova E. (2011), "Taxation in business cycle models with endogenous market structures", Master thesis dissertation, University Paris 1 Sorbonne, University Ca'Foscari Venice. [online at http://erasmus-mundus.univ-paris1.fr/fichiers_etudiants/4596_dissertation.pdf accessed 09 July 2013].

Sustainable Development Reporting: International and Russian Experience*

Olga EFIMOVA, Ph. D., Professor
Economic Analysis Department, Financial University, Moscow
oefimova2002@mail.ru

Nadezda BATYROVA
Economic Analysis Department, Financial University, Moscow
nsbatyrova@yandex.ru

Abstract. In recent years, the phenomena of Sustainable Development have been explored in an extensive body of theoretical and empirical research. In order to inform all interested users and to evaluate their own success in achieving the long-term sustainability targets, companies draw up Sustainable Development Reporting (SDR). Although the literature suggests many possible approaches to accounting for sustainability, there is no consensus on the best way forward. This article analyzes methodology and best practice of SDR. In particular, 47 Russian companies' SD reports were analyzed; that helped find out their main features. The study helped to outline strengths and weaknesses of SDR in Russia. The results of international SDR best practice analysis were taken into account. Our findings show positive trend in the number and growing quality of SD reports provided by Russian companies. The analysis of SDR best practice helped us to recommend key performance indicators of sustainable development that can be used by small and medium-sized entities in their practice.

Аннотация. В последние годы феномен устойчивого развития рассматривался в значительном числе теоретических и эмпирических исследований. В целях информирования всех заинтересованных пользователей, а также для того, чтобы оценить собственные успехи в достижении долгосрочных целей устойчивого развития, компании разрабатывают отчет об устойчивом развитии (SDR). Хотя в литературе предлагаются многочисленные возможные подходы к учету устойчивости, можно констатировать отсутствие единого общепринятого подхода, позволяющего в полной мере решать задачи анализа устойчивого развития. В статье анализируются методология и лучшая международная практика отчетности в области устойчивого развития (SDR). В частности, были проанализированы 47 SD отчетов российских компаний, что помогло установить их основные особенности. Исследование помогло выявить сильные и слабые стороны SDR в России. Наши результаты показывают положительную тенденцию в количестве и растущее качество предоставления отчетов об устойчивом развитии российскими компаниями. Анализ лучшей практики SDR позволил нам рекомендовать ключевые показатели эффективности устойчивого развития, которые можно использовать, в том числе, в практике предприятий малого и среднего бизнеса.

Key words: Sustainability, Sustainable Development Reporting, Corporate responsibility, Indicators of Sustainability, Integrated Reporting.

1. INTRODUCTION

In recent years the issues of sustainable development became very important to the business community due to various factors. Some of these factors are:

- importance of public opinion,
- legislation proposes certain environmental restrictions,
- limitations and the rising cost of the resource base,
- competitors who have already started to work in accordance with the principles of sustainability.

All of them are pushing companies to realize the need to build up a strategy of sustainable development.

The influence of the concept of sustainable development in the investment attractiveness of the business cannot be overestimated. A forward-looking portfolio investor looks at the entire spectrum of risks, including non-financial. The company may be attractive in terms of current yield, but very unstable in environmental and social terms. Therefore, the company's value is directly linked to its environmental and other reputational risks.

* Отчетность в области устойчивого развития: международный и российский опыт

Along with the need to develop and maintain the image of a reliable company with a long-term development strategy there are other very important reasons for the company's activities to be consistent with the principles of sustainability:

- companies that intelligently and efficiently manage the resources (in accordance with the principles of sustainability) depend less on price fluctuations;
- the earlier the company takes the principles of sustainability, the greater its chances are of getting a competitive advantage in the marketplace;
- the companies undertaking a sustainable development strategy achieve long-term goal, which allows to align all key aspects of their activities, and to control the major strategic risks.

This goal can be divided into a number of targets. The most important targets are:

- the company's value creation and growth;
- strengthening of positive image and reputation;
- efficient use of resources (financial, material, labor) and providing the required return on invested capital;
- development of policies aimed at staff development, health care of employees, healthy and secure environment, motivation increasing;
- development of environmental policies and responsible use of natural resources.

Realizing the need of an integrated approach to sustainable development, it is important to consider the presence of very significant problems that complicate the implementation of the concept in practice.

Let us to consider the most important among them.

Problems of the methodology: the lack of developed conceptual framework which is necessary to manage long-term sustainability, including the conceptual basis, knowledge base, common reporting content and a set of particular indicators.

As a result, there is no common language that would allow the business community to discuss issues related to sustainability.

Problems of implementation of the concept of sustainable development:

- there is no integrated approach to manage long-term sustainability at the company level. Their efforts are local;
- companies do not have enough information on which they will be able to base their decisions;
- there are no developed techniques for the analysis of long-term sustainability;
- there are no generally accepted indicators for the analysis of long-term sustainability. As a result, the organizations lack understanding of how to determine whether they have succeeded in solving related tasks;
- the major part of analyzed companies use only a specific set of financial and non-financial indicators, but there is no systematic approach for it.

Another group of issues are related to difficulties in implementing the concept due to common economic reasons:

- long-term development strategy is investing in a very long period and it is difficult to calculate the benefits using the traditional approach;
- the advantages and opportunities that a company can get are often highly uncertain;
- some managers are not able to control such issues as the impact of their business on the environment, region, society as a whole;
- per common economic reasons it is rather difficult to put the principles of sustainability as a major issue on the agenda of the company. And, of course, the main difficulty is connected with performance evaluation related to participation in sustainable development.

Along with this, the issues that are more specific to Russia should be noted, including:

- low transparency of Russian business;
- weak involvement of small and medium-sized businesses;
- lack of guidelines and practice (except for public companies) for sustainable development reporting.

We will try to assess the situation on each particular issue in order to provide a possible solution.

2. BACKGROUND & THEORY

The term "sustainable development" (SD) has been widely used after Prime Minister of Norway Gro Harlem Brundtland's speech at the UN in 1987. The UN Report *Our Common Future*, better known as *Brundtland Report,* defined SD as "development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations" (WCED, 1987, p. 43).

The Brundtland Report coined SD as an integrative concept aiming to balance environmental and economic issues in a mutually beneficial way. It outlined SD as an environmental concept for the macroeconomic level (Steurer, 2002, pp. 241ff, pp. 341–366). Regarding its thematic breadth, issues other than strictly environmental ones were incorporated.

While initially economic and social issues were addressed only as far as they were perceived to be relevant for environmental concerns (Steurer, 2001), they evolved into equally important dimensions of SD. Regarding its conceptual principles, the idea was expanded from the macroeconomic to the microeconomic and individual level. This application of SD on the corporate level is often referred to as Corporate Sustainability (CS).

CS is a corporate guiding model, addressing the short- and long-term economic, social and environmental performance of corporations (firms).

Today, CS is a well-known societal guiding model that asks for the integration of economic, social and environmental issues in all societal spheres and levels in the short- and long-term.

SD AND STAKEHOLDER CONCEPT

Stakeholder theory is built upon the idea that businesses should serve a variety of interests rather than just those of shareholders. In short, stakeholder theory suggests that "there is a multiplicity of groups having a stake in the operation of the firm — all of whom merit consideration in managerial decision making" (Phillips,1997, p. 52).

Freeman could be considered to be the modern day founder of the concept via his 1984 book *Strategic Management: A Stakeholder Approach.* Freeman (1984) defines a stakeholder as follows: "A stakeholder of an organization is (by definition) any group or individuals who can affect or is affected by the achievement of the organization's objectives".

Now the stakeholder concept is an analysis tool for the strategic management of companies. It is based on knowledge that there are different stakeholders both inside and outside the company that have conflicting and complementary interests which influence corporate sustainability.

As Freeman states individuals or groups can be described as stakeholders if they have a material or immaterial "stake" in the business. The stake of individuals or groups in a company is based mainly on the fact they make resources available to the company. In this case the following main types of material and immaterial resources can be outlined:

- Capital resources, such as financial assets;
- Tangible assets (land, buildings, etc.);
- Human resources;
- Natural resources;
- Goodwill resources, such as social acceptance and good working environment within the company, customer relations and so on.

It seems important to emphasize that modern integrated reporting (IR) is based on a similar approach to classify resources of the company (IIRC, 2011). So IR framework offers following elements of company's recourses (capitals):

- Financial capital;
- Manufactured capital;
- Intellectual capital;
- Human capital;
- Social and relationship capital;
- Natural capital.

As can be seen, despite some differences in the allocation of capital elements, essentially they are based on a common approach.

Stakeholders make resources available to the company as far as there is a profitable relationship between what they put into company and what they get out (Fegge, Schaltegger, 2000). This connection is a key feature of stakeholder relationships: the fact that stakeholders depend on the company to achieve their business goals and the company in turn depends on them.

As it was emphasized in numerous researches there is a deep connection between SD concept and the stakeholder theory (Steurer, Langer, Konrad, Martinuzzi, 2005), (Reynolds, Schultz, Hekman, 2006), (Lorne and Dilling, 2011) and others. Understanding the fact that SD concept has the stakeholder theory roots helps to outline drivers of company sustainable development. At the same time these factors (drivers) are considered as drivers of stakeholder value (Figge, Shaltegger, 2000).

According to this approach the factors of stakeholder value creation are following:

- value is not created solely by the organization itself or inside;
- value is under the influence of external factors, which are the risks and opportunities of the environment in which the company operates;
- value is created by joint efforts through relationships with stakeholders (customers, business communities, etc.);
- value depends on the availability, accessibility, effectiveness of resources management (financial, industrial, intellectual, natural and social).

As it was mentioned above, acceptance of these principles was the basis for the development of integrated reporting.

Sustainable business is a business that can survive in the long run. In turn, the long-term sustainability involves the providing of conditions for value creation (it is meant stakeholder value). These conditions are connected with both financial and non-financial factors.

The number of reports, articles and surveys that were published last 20 years highlight importance of non-financial drivers for sustainable development that in turn determines long term value of the company. Figure 1 represents this comprehensive approach to understanding the value creation drivers as well as direction of Non-Financial drivers' impact on key financial value drivers.

There are three key adopted areas of long-term sustainability: the economy, the ecology (environment), and the social responsibility.

In economic terms long-term sustainability is connected with providing conditions for economic value

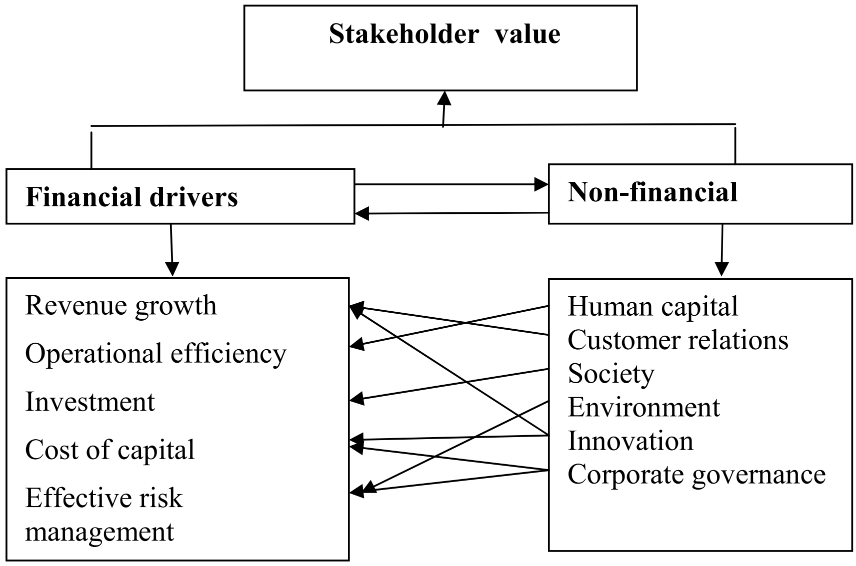


Figure 1. The Value Creation Framework

added creation. It means the company should increase return on capital employed trying to optimize cost of capital.

Social aspects of sustainability are connected with staff development (safety, stable payment of wages, additional medical and social insurance for employees, human resource development through training programs, skills development, assistance in critical situations, and maintaining image of a socially responsible employer), as well as participation in social investments through its internal and external social programs in the territories of its presence, oriented at maintaining their social well-being, security and stability.

From an environmental point of view it is the company's efforts to protect and restore the environment, including reduction of emissions and other environmental necessities.

Obviously, the problem of sustainable development at the present time can not be viewed in isolation as a separate assessment of the economic, social or environmental sustainability, but certainly in their symbiotic relationship.

Thus, the company's efforts to ensure the long-term sustainability must be organically integrated into the company's strategy. As a long-term effect of such integrity the company achieves the cost reduction, and it helps to manage three main elements of intellectual capital: relational, organizational and human capital.

3. HYPOTHESIS DEVELOPMENT

Sustainable value creation involves consideration of economic, environmental, and social factors — not only because different stakeholders have different interests, but also because these factors are interdependent. Environmental and social factors can also determine or affect the market (economic) value of a company. In turn financial factors are crucial for developing environmental and social projects of a company.

The issue of sustainable value creation cannot be solved without the appropriate information-analytical system. On the one hand it enables the company to assess the progress in achievement of long-term development key objectives, and on the other hand, it allows all interested users (stakeholders) to evaluate the intentions and the success of the company's efforts to ensure its long-term sustainability.

Stakeholders (partners, customers, shareholders, local and federal authorities, the media) are interested that the principles of sustainability are integrated into the strategy and business plans. In order to meet the expectations of stakeholders, companies need to maintain a dialogue with them, allowing to reduce reputational risk and to find new business opportunities.

This, in turn, creates the problem of choosing the form of information exchange with stakeholders. Reporting under IFRS does not solve the problem, because such statements relate to financial matters of disclosure only. Despite the fact that the voluntary disclosure of additional information in annual report is welcome, specific recommendations on non-financial information disclosure do not exist (except, perhaps, the disclosure requirements of the financial risks of the company).

There is some experience in the development of accounting, which allows to link financial and non-financial information necessary for decision making. So, it is important to mention *Guidance on Corporate Responsibility Indicators in Annual Reports published by United Nations (2008); International Guidance Document Environmental Management Accounting,* published by IFAC

(2005); *A Manual for the Preparers and Users of Eco-Efficiency Indicators,* UNCTAD (2004); *The Sigma Guidelines – Toolkit Sustainability Accounting Guide,* published by the SIGMA Project (2003).

However, using environmental management accounting requires solution of many problems. Moreover, these documents themselves indicated that this reporting is still in its infancy. There is a serious information gap, which greatly complicates the process of justification of investment and financial decisions for both internal and external stakeholders.

Key issues that will contribute to solving the problem:

- What form of information should be chosen to make it possible to satisfy the interests of sustainable development management as well as the interests of key stakeholders?
- What should the content of the report be?
- What is sustainable development business?
- How to assess the sustainability and what measures to use for this?
- What information is needed to study?
- Is this reporting reliable?
- How to evaluate the progress of the company's long-term sustainability?

For purpose to promote an integrated SDR which meets the key stakeholders needs there were a large number of studies at the international level. As a result of them new recommendations on SDR were provided from various professional organizations.

It is evident that the accountant profession plays an important role in the development of the theory and practice of sustainable development.

For example:

The Institute of Chartered Accountants in England and Wales (ICAEW) has provided guidance to its members on the type of services likely to be required in a world where sustainability reporting is commonplace.

The Chartered Institute of Public Finance and Accountancy (CIPFA) has published *Sustainability: A Reporting Framework for the Public Services*, a model of sustainability reporting that any public sector organization can apply for considering and reporting on organizational and service-level sustainability.

The Association of Chartered Certified Accountants (ACCA) and the Chartered Institute of Management accountants (CIMA) has published a variety of papers that consider how to include sustainability measures in traditional financial reporting, including Full Cost Accounting, Triple Bottom Line reporting and Balanced Scorecard methodologies, as well as a selection of hybrid approaches.

The International Federation of Accountants (IFAC) has issued guidance on environmental management accounting.

Also we should refer:

- *Sustainable Value — EABIS Research Project — Corporate Responsibility, Market Valuation and Measuring the Financial and Non-Financial Performance of the Firm*, published by European Academy of Business in Society (EABIS) in 2009.
- *KPIs for ESG — Key Performance Indicators for Environmental, Social and Governance Issues — A Guideline for the integration of ESG into Financial Analysis and Corporate Valuation* (version 3.0): published by DVFA (the Society of Investment Professionals in Germany) in 2010.
- *Guidance on Corporate Responsibility Indicators in Annual Reports*, published by UNCTAD in 2008.

In response to changes in the concept of corporate reporting the International Integrated Reporting Committee (IIRC) offered another reporting model, which will explain how business creates and sustains its value at present and in the future.

Integrated reporting model is based on the existing reporting elements, such as management discussion and analysis. It also "… brings together material information about an organization's strategy, governance, performance and prospects in a way that reflects the commercial, social and environmental context within which it operates. It provides a clear and concise representation of how it creates and sustains value (IIRC, 2011)".

Association of Certified Chartered Accountants (ACCA), International Integrated Reporting Committee (IIRC), World Business Council for Sustainable Development (WBCSD) and other bodies are actively involved in raising public awareness about benefits of informational transparency. Their activity resulted in the increase of number of reporting entities with more transparent corporate reports.

Summing up the main ideas of these documents it can be said that all of them encourage the investment community, governments, regulators and corporations to enhance the integration of environmental, social and governance (ESG) factors for capital investment decisions and to include ESG information in corporate reporting.

The literature research identifies a variety of indicators and frameworks developed to promote and reflect sustainability. For example: the Triple Bottom Line that combines economic, environmental and social considerations to promote fair operation activity, eco-efficiency, and environmental justice; the Balanced Scorecard and Sustainability Balanced Scorecard that use strategy maps to integrate sustainability into decision-making processes; and the Sustainability Assessment Model that uses the concept of full-cost accounting, translating all internal and external costs into financial values to measure the sustainability of a company's specific projects.

Although the literature suggests many possible approaches to accounting for sustainability, there is no consensus on the best way forward.

By dividing stakeholders into two groups: external and internal, it is possible to advance two hypotheses.

Hypothesis 1.The main objective of SDR for internal users is to construct a system of value creation drivers (both financial and non-financial) with the release of the most important operational and strategic risks, including reputation. Making a report on a regular basis will contribute to ongoing coordination and harmonization within the company. It also will help in providing interactions with the environment (investors, creditors, competitors, government agencies, the public), which gives an important experience, connections and advantages in the field of coordination and communication.

Hypothesis 2. The main goal of constructing a report for external users is implementation of effective information dialogue with key stakeholders on the strategy of sustainable development and also evaluating its performance in comparison with other companies.

In our research we examined the stakeholder expectations and, as a result, offered key performance indicators relevant for every group. Table 1 summarizes the most important sustainability indicators, taking into account the different goals of internal and external stakeholders.

There is no doubt that in practice the choice of particular indicators and clarifying methodology will take into account the company objectives and strategy.

Our research based on SDR and integrated reports best practice analysis helped to outline how effective the analyzed companies were in their SD strategy disclosure and how relevant such disclosures were.

4. SAMPLE, MEASUREMENT ISSUES AND FINDINGS

The analysis of international corporate reporting best practice is based on analytical reviews prepared by leading consulting companies and analytical agencies, such as PrciewaterhouseCoopers, Ernst&Young, KPMG, CorporateRegister.com, and Russian Union of Industrialists and Entrepreneurs.

In particular, for analysis of international integrated reporting practice we used results of PriceWaterhouseCoopers research, surveying 2011 corporate reports of the companies listed on Johannesburg Stock Exchange (PWC, 2011) and London Stock Exchange (PWC, 2011).

The PwC report analysed the practices of the Johannesburg Stock Exchange's (JSE) top 100 companies, 100 in the FTSE 100 and 198 in the FTSE 250. Investment trust companies were excluded from the analysis, as their more standardised reporting would skew the results.

Russian listed companies quoted on Stock Exchange MICEX do not have common practice of preparing non-financial reports. As a consequence, the sample of this research is limited to 47 reports for 2012, registered in National Register of Non-Financial Reports of Russian Union of Industrialists and Entrepreneurs as of September 10, 2012 (see Appendix 1). Information about industry structure of analyzed companies is provided in Appendix 2. Furthermore, the results of SD Index analysis provided by Interfax-Era (includes 150 Russian companies) were used.

The first Russian company which attempted to prepare integrated report was State Atomic Energy Corporation Rosatom and its subsidiaries in 2009. Nowadays Rosatom and Oil Company Rosneft OJSC are the only Russian companies participating in the initiative of International Integrated Reporting Committee. In this case these reports were analyzed more deeply.

As it is stated in the IIRC report, *Towards Integrated Reporting: Communicating Value in the 21st Century* (IIRC, 2011), an integrated report should contain, at least, six content elements summarized below. The presentation of the elements should make the interconnections between them apparent:

- Organizational overview and business model;
- Operating context, including risks and opportunities;
- Strategic objectives and strategies to achieve those objectives;
- Governance and remuneration;
- Performance;
- Future outlook.

We examined completeness and quality of information of these sections in the analyzed SDR of Russian and international companies and came to the following conclusions.

Due to the efforts of international bodies involved in raising public awareness about benefits of informational transparency, number of reporting entities with more transparent corporate reports increases.

Gradually recommendations on non-financial reporting worked out by international organizations become regulatory requirements, as it was observed in the United Kingdom and South Africa.

There is no doubt that regulation will continue to have an impact on the level of disclosure and structure of reporting, but its immediate impact on transparency is less clear. Regulation does, however, tend to increase everyone's attention on certain areas, and this, in time, drives real improvements in the quality and coherence of key information reported.

Table 1. Primary objectives of Sustainable Development Reporting and KPIs

Stakeholders	Communication goals	Performance indicators
	External	
Shareholders and creditors	Improving disclosure mechanisms Realizing enterprise fair value Operation mechanism improving and investor relationship Providing of information for making decision Reporting on management's stewardship Public relations maintaining Meeting legal and regulatory requirements A higher price/earnings ratio promotion	Value added attributable to shareholders Return on capital employed Owner interests Dividends, bond interest distribution EPS, DPS
Customers	Meeting of customer demands Undertaking of market analysis Developing and implementation of marketing programs Improving of product and process activities	Revenue generated from ten largest clients, as percentage of total revenue; Average revenue per client; Gained and lost clients during the year Length of customer relationship
Suppliers	Developing and implementing of supplier selection criteria and evaluation	Cost contract Payment Contract Contract Terms
Financial and insurance companies	Finance and insurance policy implementing Reducing finance risks	Payment schedule Compensation rates
Business Partners	Market analysis undertaking of industry and peer company Establishing of effective business partnerships	Revenue Return of capital Market share Stakeholder liaison groups
Government	Development of social infrastructure A return on capital providing New jobs creation	Taxation Creating jobs Rate of industrial accidents Contribution of Social Public Welfare
Community	Increasing of investment in social welfare Responsibility for the environment protection of natural resources	Pollution complaint cases Social welfare spending Total CO_2 emissions from energy sources Environmental improvements made this year Total waste to landfill Fresh water consumed Volume of ozone depleted substances released into the environment Cost savings from energy efficiency gains Chemicals used in production
Nongovernmental organisations (NGOs)	Strengthening of communication Establishing of effective partnerships	Promotion of the company's business
	Internal	
Employees	Meeting employee demands Effective communications undertaking Improving of employee training Improving of employee welfare Human resources development	Revenue per person Revenue per partner Productive hours worked as percentage of available time (that is, excluding holidays, sick and professional development leave, etc.) Employee training Rate of signing collective contracts Investment in human capacity development Rate of employee retention Rate of complaints closed Staff satisfaction Lost time injuries Length of employee service
Owners and Management	Development of quantifiable measures of performance in terms of strategic and operational goals meeting Risks and rate of return evaluation Verifying of information from other sources Forecasts making Analysis of industry sector	EBITDA ROCE EPS EVA

Our findings show that reporting entities appear to be taking a broad-based approach without providing sufficient detail in important aspects.

Other areas for improvement lie in establishing connection between key content reporting elements and rationalization volume of reported information. The study found that the vast majority of companies disclose large volumes of information but that much of it may not be material. So, companies must seek for the balanced approach, since excessive disclosure makes perceiving information complicated. On the other hand, superficial disclosure of key company's value drivers has adverse impact on the effectiveness of integrated reporting.

Therefore, it is worth emphasizing the importance of raising public awareness and popularization of integrated reporting.

As for Russia, the greatest achievement of our reporting practice is positive trend in the number of corporate reports. Thus, according to Russian Union of Industrialists and Entrepreneurs, as of the beginning of 2008 there were 55 companies registered in the National Register of Non-Financial Reports, which issued in total 113 reports (since 2000), and as of September 10, 2012–121 companies published 389 reports. Leaders of corporate reporting are the companies of energy, oil and gas and finance industries — 34, 14 and 16 reports respectively.

The analysis of SDR content has shown the following main aspects. Description of the company profile is mandatory. This section is presented in all SDR — both Russian and foreign companies. Analyzing the economic component of SDR it should be noted that this section has a large number of interpretations.

Furthermore, we can identify the relationship between the target audience and, consequently, the reporting objectives and those indicators that the company uses. For example, one of the largest Russian oil companies OAO Lukoil's report reflects company's contribution to the socio-economic development in the regions where it operates, opportunities and barriers faced by the company, as well as the impact of legislative regulation of the major economic indicators. The other Russian oil company OAO Rosneft provides the same disclosure.

Environmental dimension of sustainable development is the most developed and widely recognized. Almost all companies include aspects of efficient use of natural resources and reduction of harmful environmental impact in their reports. Most reports disclose principles and strategies of environmental policy implementation.

Some of the commonly used indicators should be mentioned: the percentage of materials used that are wasted, direct energy use and energy consumption, impacts of company's activities and operations on protected and sensitive areas, greenhouse gas emissions, total amount of waste by type and destination, penalties for non-compliance with all applicable regulations associated with environmental issues.

Considering the other part of SDR — a social component — it is possible to distinguish two main blocks of this section: human resources and social responsibility.

In general, social indicators include: health protection, improving working conditions, skills and qualifications increase, building a system of relationships with customers, respect for human rights and development of cooperation with local communities.

Of course, different companies include various social indicators. Indicators of social policy in respect of employees and charitable activities are the most common for Russian companies.

Summarizing, we can conclude that all analyzed Russian companies accept the need for practical implementation of sustainable development.

GRI standard is applicable and useful for the reporting of sustainable development in the Russian context by structuring and social orientation. To spread the reporting of sustainable development further it is necessary to involve small and medium businesses into the process.

Taking into consideration best practice international corporate reporting, we can distinguish such areas for improvement as business analysis, strategic plans and important decisions in connection with macroeconomic analysis and company's strategic objectives. In order to make a report easier to interpret, it would be advisable to describe external factors analysis and its impact on the business strategy.

Based on the results of our survey, we came to a conclusion that Russian companies included a rather superficial external factors analysis without disclosing any measures to mitigate macroeconomic risks.

Taking into account the reporting practice of foreign companies we would recommend domestic entities to put attention on improvement of economic analysis, include their vision of industry development in the nearest future, in connection with their own strategy and relevant issues of industry and country as a whole.

Quality of risks disclosure in the reports of Russian companies has been increasing during the last decade. Most of organizations prepare explicit risk profile with risk management description. However, in our opinion, the integrated report would have benefited from qualitative perspective, if it contained quantitative analysis of possible financial outcomes of the identified risks. The inclusion of the required or budgeted levels of key performance indicators gives a stakeholder an opportunity in the next reporting period to compare actual results with budgeted amounts. This, in turn, would allow making an unbiased assessment of KPIs trend.

For summary overview of sampled corporate reports broken down by the set forth elements, please refer to Appendix 3.

5. CONCLUSION

Let us sum up. Sustainable development of the company is a new management concept, which assumes that any economic decision should take into account economic, environmental and social effects. To implement it, companies need a strategic business approach to managing economic, social and environmental sustainability.

In order to inform all interested stakeholders and to evaluate their own success in achieving the long-term sustainability targets, companies draw up SDR. Although the literature suggests many possible approaches to accounting for sustainability, there is no consensus on the best way forward.

We analyzed 47 SD reports of Russian companies, registered in National Register of Non-Financial Reports of Russian Union of Industrialists and Entrepreneurs. For purpose of comparative analysis the results of SD Index provided by Interfax-Era (includes 150 Russian companies) were used.

Our findings show positive trend in the number and growing quality of corporate reports providing by Russian companies. As result of our analysis we can conclude that all Russian companies attempt to provide information reflecting key aspects such as business model, risks and opportunities, strategic objectives and strategies to achieve those objectives, governance and remuneration, performance, future outlook. At the same time, we must admit that such disclosure is often a formality. First of all, it concerns information about the risks and risk management, remuneration and forecast.

It is clear that implementation of such an expensive project as development and publication of the SDR in accordance with the standard of GRI or IR is possible for large companies only. At the same time, the reporting principles can be used by small and medium-sized businesses in order to establish an effective dialogue with business partners, representatives of the legislature. Compiled in an acceptable form, SDR can be a tool of corporate governance, brand formation, business risk minimization, which ultimately enhances the effectiveness of overall business and its long-term sustainability. Analysis of SDR best practice helped us recommend key performance indicators of sustainable development that can be used by small and medium-sized entities in their practice.

REFERENCES

Association of Chartered Certified Accountants — ACCA & Deloitte (2010), "Hitting the notes, but what's the tune? An international survey of CFOs' views on narrative reporting", Research Publications, London.

Bebbington, J. (2007), *Accounting for Sustainable Development Performance*, London: Elsevier.

Bell, S. & Morse, S. (2008), *Sustainability Indicators: Measuring the Immeasurable?* (2 ed.), London: Earthscan.

Berman, J. E. & Webb, T. (2003), *Race to the top: attracting and enabling global sustainable business,* Washington: World Bank Group.

Boston Consulting Group — BCG (2012), "The 2012 Value Creator report — Improving the OODS: Strategy for superior value creation", Research Publications.

CFA Institute (2007), "A Comprehensive Business Reporting Model: Financial Reporting for Investors", Research Publications, Charlottesville.

Deloitte (2009), "A Telling Performance: Surveying Narrative Reporting in Annual Reports", Research Publications, London.

Deloitte (2008), "Write from the Start: Surveying Narrative Reporting in Annual Reports", Research Publications, London.

Department of Energy & Climate Change — DECC & Department for Environment, Food and Rural Affairs -DEFRA of the UK Government (2009), "Guidance on How to Measure and Report Your Greenhouse Gas Emissions", London.

Department for Environment, Food and Rural Affairs — DEFRA of the UK Government (2010), "Measuring progress. Sustainable development indicators", National Statistics Compendium publication, London.

Duinker, P. & Greig, L. (2007), "Scenario analysis in environmental impact assessment: improving explorations of the future", *Environmental Impact Assessment Review* **27** (3), 206–219.

Dunphy, D. D., Griffiths, A. & Suzanne, B. (2007), *Organizational Change for Corporate Sustainability: A Guide for Leaders and Change Agents of the Future* (2 ed.), London: Rountledge.

Enhanced Business Reporting Consortium — EBRC, (2006), *The Enhanced Business Reporting Framework* (exposure draft: version 2.1), Washington DC.

Federation of European Accountants — FEE (2011), "Environmental, Social and Governance (ESG) indicators in annual reports. An introduction to current frameworks", Research Publications, Brussels.

Fonseca A. (2010), "How credible are mining corporations' sustainability reports? A critical analysis of external assurance under the requirements of the international council on mining and metals", *Corporate Social Responsibility and Environmental Management*, 17 (6), pages 355–370.

Friedman, A. L. & Miles, S. (2006), *Stakeholders: Theory and Practice*, New York: Oxford University Press.

Global Reporting Initiative — GRI (2006), "Sustainability Reporting Guidelines: Version 3.0", http://www.globalreporting.org/

Gibson, R. B., Hassan, S., Holtz, S., Tansey, J. & Whitelaw, G. (2005), *Sustainability Assessment: Criteria and Processes,* London: Earthscan.

Gray R. & Bebbington J. (2007), "Corporate sustainability: accountability or impossible dream?", in G. Arkinson, S. Dietz & E. Neumayer (Eds.) *Handbook of Sustainable Development*, Cheltenham, Northampton: Edward Elgar

Henriques, A. (2007), *Corporate Truth: The Limits to Transparency*, London: Earthscan.

Henriques, A.,& Richardson, J. (2004), *The Triple Bottom Line: Does it All Add Up?,* London: Earthscan.

Institute of Chartered Accountants in England and Wales — ICAEW (2009),"Development in new reporting models. Information for Better Markets", Research Publications, London.

International Corporate Governance Network — ICGN (2008), "Statement and Guidance on Non-Financial Business Reporting", Research Publications, London.

International Federation of Accountants — IFAC (2011), "Sustainability Framework 2.0. Professional Accountants as Integrators", Research Publications, New York.

International Federation of Accountants — IFAC (2009), "Developments in the Financial Reporting Supply Chain: Results from a Global Study among IFAC Member Bodies", Research Publications, New York.

International Integrated Reporting Committee — IIRC (2011), "Towards integrated reporting: Communicating Value in the 21st Century", Research Publications, http://www.theiirc.org/.

KPMG (2003), "Building a New Reporting and Communications Model: A New Source of Competitive Advantage", Research Publications, Melbourne.

KPMG (2008), "International survey of corporate responsibility reporting 2008", Research Publications.

MacLean, R., & Rebernak, K. (2007), "Closing the credibility gap: The challenges of corporate responsibility reporting", *Environmental Quality Management,* **16** (4), 1–6.

Perrini, F. & Tencati, A. (2006), "Sustainability and stakeholder management: The need for new corporate performance evaluation and reporting systems", *Business Strategy and the Environment,* **15** (5), 296–308.

PricewaterhouseCoopers — PWC (2007), "Corporate Reporting: Is It What Investment Professionals Expect?", Research Publications, London.

PricewaterhouseCoopers — PWC (2008), "Recasting the Reporting Model: How to Simplify and Enhance Communications", Research Publications, London.

PricewaterhouseCoopers — PWC (2011), "Greater disclosure but little insight under new code", Research Publications, http://www.pwc.com/gx/en/corporate-reporting/integrated-reporting/corporate-reporting-south-africa-king-iii.jhtml.

PWC (2011), "Corporate reporting: from compliance to competitive edge", Research Publications, http://www.pwc.com/gx/en/corporate-reporting/integrated-reporting/index.jhtml.

Russian Union of Industrialists and Entrepreneurs (2012), "National Register of Non-Financial reports".

Russian Union of Industrialists and Entrepreneurs — RUIE (2012), "Increasing informational transparency of business through development of corporate Non-Financial reporting", Analytical review of corporate non-financial reports for 2008–2012.

The Prince's Charities (2009), "Accounting for Sustainability, Connected Reporting in Practice: A Consolidated Case Study", Research Publications, London.

UNCTAD (2008), "Guidance on Corporate Responsibility Indicators in Annual Reports", Research Publications, New York & Geneva.

Werbach, Adam (2009), "When Sustainability Means More Than Green", *McKinsey Quarterly*, Issue 4, p. 74–79.

WBCSD (2005), "Sustainable development reporting. Striking the balance", Research Publications, Geneva.

Appendix 1

Integrated (non-financial) reports in Russia (at September 10, 2012)
(According to the Russian Union of Industrialists and Entrepreneurs)

Industry	IR*	SDR**	SR***	ER****	Total
Housing and communal services			1		1
Mining and metals	1	2	1		4
Non-for-profit organizations	1				1
Oil and gas		8		1	9
Health care and education			1		1
Food manufacturing		1	3		4
Other services		2			2
Telecommunications			3		3
Finance and insurance			5		5
Chemicals, petrochemicals and perfume	2	1	2		5
Energy	7	3	2		12
Total	**11**	**17**	**18**	**1**	**47**

*IR — integrated report, **SDR — sustainable development report,
***SR — social report, ****ER-ecological report.

Appendix 2

Industry structure of non-financial reports in Russia
(According to the Russian Union of Industrialists and Entrepreneurs)

Industry	Amount of non-financial reports prepared	Share in total,%
Energy	12	26%
Oil and gas	9	19%
Finance and insurance	5	11%
Chemicals, petrochemicals and perfume	5	11%
Mining and metals	4	9%
Food manufacturing	4	9%
Telecommunications	3	6%
Other services	2	4%
Housing and communal services	1	2%
Non-for-profit organizations	1	2%
Health care and education	1	2%
Total	**47**	**100%**

Appendix 3

Executive summary of integrated reporting overview

Content element	International companies	Russian companies	Comments	Recommendations
Organizational overview and business model	+	+	Most international companies provide description of their business model, although a limited number of entities support their statement with detailed commentary or measures. The vast majority of Russian companies (67%) describe their business in conformity with GRI, however, business model narrative is rather disconnected with no or limited presentation of key value drivers.	To provide a more explicit description of business model highlighting key value drivers and key aspects of business as a comprehensive system.
Operating context, including risks and opportunities	+	+	International companies' risk profiles are traditionally prepared at a high level quality, although this element should be showed in connection with other aspects, such as strategic priorities, external trends, and performance. The Russian companies also prepare an explicit risk profile describing nature of risks and mitigating measures. Nonetheless, both international and Russian reporting entities failed to provide a detailed quantitative analysis.	To provide quantitative analysis of possible financial outcomes of the identified risks.
Strategic objectives and strategies to achieve those objectives	+	+	Both international and Russian companies disclose strategic objectives in their reports. However, further improvements should be implemented by demonstrating a link between external drivers and opportunities and company's strategic choices.	To integrate strategic themes and intent throughout report supporting it with quantitative analysis.
Governance and remuneration	+	+	International companies traditionally demonstrate best practice in governance and remuneration disclosure. The Russian companies also provide a very qualitative disclosure on corporate governance, although information about remuneration is either omitted at all, or presented in a condensed form. A very limited number of companies disclose total amount of key management personnel remuneration and total amount and average salary of other personnel.	For the Russian companies — to strengthen disclosure on remuneration of key management personnel, for all entities — to demonstrate relationship between the remuneration policy and corporate strategic objectives.
Performance	+	+	Both international and Russian companies provide an explicit and qualitative disclosure of key performance indicators system, yet a limited number of them clearly define and provide a rationale for KPIs.	To provide trend analysis and explain the underlying drivers that caused major changes in KPIs, align KPIs with strategic priorities, provide a detailed set of measures to monitor progress in delivering strategic priorities.
Future outlook	+	+	Both international and Russian companies nominally include a separate paragraph with information about future plans and prospects. However, narrative is rather vague and not backed up by quantitative information.	To provide quantitative information about future outlook, emphasizing key drivers of the current and future growth.

Real Options Model of RES Policies Benefits in Russian Federation*

Denis ZELENTSOV
International Finance Faculty, Financial University, Moscow
denis.zelentsov@yandex.ru

Inna LUKASHENKO
Head, International Financial Laboratory, International Finance Faculty, Financial University, Moscow
IVLukashenko@fa.ru

Alexandra AKHMETCHINA, Ph.D.
Deputy Dean, International Finance Faculty, Financial University, Moscow
AAkhmetchina@fa.ru

Abstract. Shift of energy consumption structure towards increase of Renewable Energy Resources (RES) share is one of the goals of national energy strategy of Russian Federation. While such shift could bring many positive implications, all of them falling in one of the standard bins of sustainability triad, a need for proactive position of government in RES promotion is undeniable, as egoistic rational motivation of individual economic agents stops them from spending resources on altruistic goals of sustainable development. Rigorous cost-benefit analysis of RES support strategies could be cumbersome if possible at all, as assessment model should address numerous intricacies of policy design and uncertainties of innovation process, energy market and new technology adoption. We develop real options model to address at least several mentioned complexities, and analyse RES support policy options to recommend the best for Russian Federation.

Аннотация. Изменение структуры потребления энергии в части увеличения доли возобновляемых источников энергии (ВИЭ) является одной из целей национальной энергетической политики России. Несмотря на то что от такого изменения, вписывающегося в перспективу повышения устойчивости развития, выиграют все потенциальные стейкхолдеры, государство должно занимать более активную позицию в продвижении ВИЭ, так как рационально действующие экономические агенты эгоистичны, а следовательно не могут тратить свои ресурсы на альтруистические цели. Точное измерение эффекта государственной политики поддержки ВИЭ сложно, если вообще возможно, с учетом всех тонкостей механизмов поддержки и неопределенностей, связанных с инновационными процессами и рынками энергии. В нашем исследовании мы разрабатываем модель реальных опционов, которая учитывает некоторые из перечисленных моментов, и анализируем различные альтернативные политики поддержки ВИЭ в Российской Федерации для того, чтобы определить лучшую.

Key words: real options, policy impact assessment, cost-benefit analysis, RES support, energy policy.

INTRODUCTION

Shift of energy consumption from non-renewable to renewable energy sources are intensively discussed during several last decades. Implications of such shift might include stabilizing world energy market, higher energy security level, decreased GHG emissions, increased environment protection, positive impact on unemployment due to creation of new industry sector, and further decrease in costs of RES implementation, representing society adaptation and optimization.

To answer these questions, the policymakers and representatives of business and academia should concentrate on direct economic costs and benefits for economic agents, economic externalities, and other effects beyond purely economic rationale. Generally, all these costs and benefits fall into well-known triad of sustainable development (economic, environmental and social factors). It is considered that government should take more proactive role in balancing these factors, as individual agents, rationally acting on their own, may lack altruistic

* Модель реального опциона для оценки эффективности государственной поддержки ВИЭ в Российской Федерации

motivation to spend additional resources. Taking into account the advantages of RE, many countries design dedicated energy policies aimed at business, households and overall society. Possible policy palette includes feed-in tariffs (FiT) and R&D subsidies. FiT promotes RES penetration by providing incentives from benefit side; R&D subsidies, on the opposite,— by providing incentives on the costs side.

There are various ways of implementation of FiT. Generally speaking, FiT is any artificial positive externality, created by government for suppliers and/or consumers of RES. In some cases, consumers may pay for gross consumption of energy to energy suppliers, and are compensated by government for using energy from RES; in other cases suppliers are paid for energy generated from certified RES sources; and, finally, there are implementation cases combining features of the first two (as in case of household, deploying wind farm or solar array, supplying excess energy to the grid on windy/sunny days, and covering lack of energy from the grid on less windy/sunny days).

From the purely economic point of view, costs on RE mainly depend on initial investments on installation, maintenance cost and climate factor. We may consider RE as dependent on the level of implemented technology, but free from finite resources prices. NRE costs, on the opposite, depend both on prices of resources and on technology. At present RE is generally more expensive than NRE. Additional investments in R&D should be endeavored to lower NRE costs. Benefit from implementing new RE is not an externality. Investments in R&D could be enormous and unpredictable. In this research we consider direct governmental subsidies for R&D to lower RE (electricity) generation costs. The cumbersome issue here is in choice between investments in R&D of new RE technology to decrease RE costs, and continuation of NRE usage.

Let's assume that every year the government invests in R&D. Through some years government may choose between abandoning the project, or continuing R&D, or deploying R&D results. Result of deployment depends very much on market penetration of deployed RE technology. It means that RE costs, decreased as result of R&D and FiT offered by government, allow the potential RE generator to obtain benefit. So we obtain the significant condition of RE diffusion: under concrete FiT level technology will be used by private entity only if it will be profitable.

The subject of this research is the overall benefit of FiT-based RES policy in presence of R&D expenses. There are some works in this area. In Lee & Shih (2010) overall value of policy in Taiwan has been evaluated, experience curves have been taken into consideration, but no direct spending on R&D. We will not consider such curves, instead using levelized costs and taking that after deployment, without R&D, they cannot be reduced. From one side, this is for model simplification; from other hand for public sector (business, homeowners, and smaller plant) it may be omitted. In Siddiqui, Marnay & Wiser (2005) the case of United States has been considered. Experience curves are not taken into consideration. This work rather assesses policy for private investor, not for economy overall. Both of these works use real options analysis for policy valuation. In current research we will use results from these two papers, augmenting it with condition of RE diffusion.

In subsequent sections, we will briefly review literature on the topic, develop the mathematical model for financial valuation using real options approach, and assess policy alternatives for renewable energy in Russian Federation. In final section we conclude and discuss implications.

LITERATURE REVIEW

Energy efficiency, including RE and NRE comparison. Advantages and disadvantages of RE are provided, for example, in: Ardente *et al.* (2008), and International Energy Agency (2005). RE allows reducing CO_2 emissions to the environment and may be generated anywhere depending only on natural limits, which leads to cost reduction of energy delivery, avoidance of energy loss and improved energy efficiency. Also energy diversification leads to higher energy security. From other hand, some traditional energy should be saved as reserve and technological reserve, and RE overall is most expensive. The main disadvantages of NRE: costs highly depend on price of non-renewable resources. The separate part of RE costs is technology and experience curves (International Energy Agency, 2000). It means that during implementation and continuous use the costs have potential to be reduced "automatically" as effects of "learning-by-doing" and "learning-by-searching" (Lee & Shih, 2010). This may also be considered as "self-optimization" of technology and society together.

In International Energy Agency (2005), many questions related to energy policy efficiency have been described with the following recommendations to energy policy-makers, program managers and analysts:

- Take into account the direct and economy-wide rebound effects when estimating the energy savings resulting from energy efficiency improvements;
- Maximize the number of households and businesses that participate in energy efficiency policies

and programs, and ensure that low-income households are well-served and benefit;

• Continue to analyse the cost-effectiveness of energy efficiency policies and programs using discount rates that are used to analyse other government or utility investment options, typically real discount rates in the range of 4 to 8%;

• Analyse the full costs and benefits of energy efficiency policies and programs, including the transaction costs and non-energy benefits.

Policy design on the basis of Feed-in-Tariff. Regarding FiT-based RE policy design here are information and recommendations: Cory *et al.* (2009), Couture *et al.* (2010), and Couture, Cory *et al.* (2010). These resources describe FiT-based RE policy as one of the most effective one with reference to the best practices in United States, Germany, Spain, Italy and other European Union countries. In these articles various schemes of FiT implementations are described with conclusion that FiT level assignment, which is based on levelized RE costs, is most popular because of its simplicity and transparency. Also here various ways of FiT funding are provided. Ratepayer scheme is most effective and therefore will be considered in detail in this work.

So we have reviewed literature for policy definition, design and implementation. In this resources RE and NRE are compared, technology and experience curves are considered. And we can continue with RE policy evaluation.

Methodologies for RE policy evaluation. Methodologies of RE policy evaluation may be divided in two main categories: first, which is based on extension of traditional discounted cash flow (DCF) analysis, and second, which is based on real options analysis (ROA).

In Bode-Greuel *et al.* (2005), DCF has been expanded to evaluate project with consideration of uncertainties in business. Quantitative financial evaluation of drug development and technology platforms in biotechnology companies have been evaluated by taking into consideration the probabilities of successful completion of various stages of the project. The suggested evaluation approach, as noted, may be useful for internal project prioritization purposes, for licensing negotiations and for investors, who wish to facilitate financing discussions and to support the definition of exit strategies.

Use of real options analysis for RE policy evaluation. General information about ROA valuation may be found, for example, in Han & Lenos (2004), Mun (2002, 2003).

There are resources related to RE policy assessment using ROA: Fan *et al.* (2010), Lee *et al.* (2010), Siddiqui *et al.* (2005).

In Fan *et al.* (2010) ROA is used for analyzing the effects of government climate policy uncertainty on private investors' decision-making in the power sector. It presents an analysis undertaken by the International Energy Agency (IEA) that implements ROA within a dynamic programming approach for technology investment choice.

Lee *et al.* (2010) considers the case of Taiwan. The significant moment of this work is that the policy is assessed in connection with overall policy value for society. Feed-in-Tariff and experience curves are taken in consideration. But there are no investments in R&D directly in this article. Obtained result has been compared with result given by methodology of Bode-Greuel *et al.* (2005). Difference is high because the extension of traditional DCF is insufficient to model non-renewable resources prices.

In Siddiqui *et al.* (2005), some variants of yearly decisions are taken into consideration. But from other hand, no FiT and experience curves in this work and valuation are done generally for plant, the RE generator. This work uses results of Brennan *et al.* (1985), where difficulties of evaluation of mining and other natural resource projects have been indicated because of high degree of uncertainty. By extending the set of decisions at each period to include the possibility of abandonment, Brennan *et al.* (1985) applies the options pricing method to their copper mine problem. Siddiqui *et al.* (2005) have generalized mining problem to benefits analysis of US Federal government funded R&D programs for RE technology improvement.

Both Lee *et al.* (2010) and Siddiqui *et al.* (2005) use discrete binomial lattice variant of ROA. But there is more general variant based on Partial Differential Equations (PDE) (Davis *et al.,* 2003). Siddiqui *et al.* specify that for financial managers, policy makers, and other users of the model it is not possible to use "black-box" model based on PDE. Of course, PDE model has high scientific value, but risks related with solution of such equations are high, and risks are increased during complication of the model, if necessary (and in this work we will do this). So, discrete binomial lattice variant seems like the middle between scientific and practical.

As during strategy preparation various possible scenarios should be analyzed, there is a problem to use traditional evaluation approach such as Discounted Cash Flow (DCF) because of its lack of flexibility and failure to account for variety of scenarios. Real options are well-known for their ability to overcome above mentioned difficulties, and have been used in similar context several times: Fan *et al.* (2010); Siddiqui *et al.* (2005, 2010); Szolgayova *et al.* (2008); Kumbaroglu *et al.* (2004, 2008); Lee *et al.* (2010).

THE MODEL

Real options method has been chosen in this research as the most effective model for valuation with uncertainty. Binomial lattice variant of real options analysis is applied for modeling. Assumptions of the model are:

- The policy is designed for normal energy users, such as households and businesses.
- FiT is simply a premium over RE levelized cost.
- FiT is shared between non-RE consumers and collected via bills.
- This additional charge has no significant impact on total electricity price.
- No technical risks, and effect from switching costs.

Under these assumptions a financial model for valuation of RE policy, based on FiT introduction, has been created. Significant feature of this model is: model takes into consideration conditional market penetration of new RE technology.

All results of the model are obtained as decision tree, which may be helpful for controlling further policy implementation.

Let's define that *t* means year, *m* means number of NRE price (RUB/kWh) movement. For example, $NRE(t, m)\,|_{t=3,\,m=2}$ means NRE price in year 3, if scenario of possible price movement in this year, 2, will be realized.

V will be overall policy value, RUB, *V (t, m)* means policy value at time moment *t* and NRE price movement *m*. So *V (1, 1)* means policy value at start.

Other financial model parameters: *I(t), D(t), A(t)*— all in RUB and, accordingly, investments, deployment costs, abandonment costs in year *t*.

β means discount factor, *p* and *q* are probabilities for binomial tree of NRE price volatility, and *up* — maximum of one up-movement of NRE price according to binomial lattice.

FiT — Feed-in-Tariff, RUB/kWh, *RE* — cost of RE technology, RUB/kWh, *L* — number of years with fixed Feed-in-Tariff (guarantee of FiT), *T* — life-time of policy in years. One more variable is used in the model: *d* means time when technology has been deployed.

There is significant condition of successful policy realization: FiT should be profitable for users. In Siddiqui *et al.* (2005) and Lee *et al.* (2010) this is considered as unconditional market penetration of new RE technology. We will consider this as a function:

$$G(t,m,d) = g\cdot\theta_0\Big(up^{2m-1-t}\cdot Z_1 - B\cdot\big(RE(d)+max\{FiT-RE(d),0\}\big)\Big),$$

where g means the maximum of penetration, kWh/a, and $\theta_0(x)$ — Heaviside step function:

$$\theta_0(x)=\begin{cases}0, & x\le 0;\\ 1, & x>0.\end{cases}$$

Next, we will introduce overall policy value for fixed FiT:

$$\begin{aligned}W(t,m,d) = {} & [up^{2m-1-t}\cdot Z_1 - B\cdot(RE(d) - max\{FiT - RE(d),0\})]\cdot G(t,m,d)\\ & + \theta_0(T-t)\cdot\beta\cdot\big(p\cdot W(t+1,m+1,d) + q\cdot W(t+1,m,d)\big).\end{aligned}$$

This function is highly dependent on previous functions, meaning that if FiT is profitable for consumers it is reasonable to introduce it.

Using these parameters, variables and functions we have constructed the following model for policy value as function of time and price of NRE:

$$V(t,m) = max\left\{\begin{matrix}-I(t) + \theta_0(T-t)\cdot\beta\cdot\big(p\cdot V(t+1,m+1) + q\cdot V(t+1,m)\big),\\ -D(t) + W(t,m,t),\\ -A(t)\end{matrix}\right\},$$

$$t = \overline{1,T},\ \ m = \overline{1,t},$$

where

$$W(t,m,d) = [up^{2m-1-t} \cdot Z_1 - B \cdot (RE(d) - max\{FiT - RE(d), 0\})] \cdot G(t,m,d) + \theta_0(T-t) \cdot \beta \cdot \big(p \cdot W(t+1, m+1, d) + q \cdot W(t+1, m, d)\big),$$

$$G(t,m,d) = g \cdot \theta_0\big(up^{2m-1-t} \cdot Z_1 - B \cdot (RE(d) + max\{FiT - RE(d), 0\})\big),$$

$$t = \overline{d,T}, \;\; m = \overline{1,t}, \;\; d = \overline{1,T} \;\; for \;\; W(t,m,d) \;\; and \;\; G(t,m,d),$$

$$Z_1 = Z(1,1), \quad B = \sum_{t=1}^{L} \beta^{t-1},$$

$$Z(t,m) = up^{2t-1-m} \cdot NRE_1 + \theta_0(L-t) \;\cdot \beta \cdot \big(p \cdot Z(t+1, m+1) + q \cdot Z(t+1, m)\big),$$

$$t = \overline{1,L}, \;\; m = \overline{1,t}$$

and $\theta_0(x)$ — Heaviside step function:

$$\theta_0(x) = \begin{cases} 0, & x \leq 0; \\ 1, & x > 0. \end{cases}$$

So, from final formalization above, we obtain overall policy value at start:

$$V(1,1) = max \begin{Bmatrix} -I(1) + \theta_0(T-1) \cdot \beta \cdot \big(p \cdot V(2,2) + q \cdot V(2,1)\big), \\ -D(1) + W(1,1,1), \\ -A(1) \end{Bmatrix},$$

where

$$W(1,1,1) = [Z_1 - B \cdot (RE(1) - max\{FiT - RE(1), 0\})] \cdot G(1,1,1) + \theta_0(T-1) \cdot \beta \cdot \big(p \cdot W(2,2,1) + q \cdot W(2,1,1)\big),$$

$$G(1,1,1) = g \cdot \theta_0\big(Z_1 - B \cdot (RE(1) + max\{FiT - RE(1), 0\})\big),$$

$$Z_1 = Z(1,1), \quad B = \sum_{t=1}^{L} \beta^{t-1},$$

$$Z(1,1) = NRE_1 + \theta_0(L-1) \;\cdot \beta \cdot \big(p \cdot Z(2,2) + q \cdot Z(2,1)\big),$$

and $\theta_0(x)$ — Heaviside step function:

$$\theta_0(x) = \begin{cases} 0, & x \leq 0; \\ 1, & x > 0. \end{cases}$$

In other points, for example, in year 2, if NRE prices have been decreased:

$$V(2,1) = max\begin{Bmatrix} -I(1) + \theta_0(T-1)\cdot\beta\cdot\big(p\cdot V(3,2) + q\cdot V(3,1)\big), \\ -D(1) + W(2,1,2), \\ -A(1) \end{Bmatrix},$$

where

$$W(2,1,2) = [Z_1 - B\cdot(RE(2) - max\{FiT - RE(2), 0\})]\cdot G(2,1,2) \\ + \theta_0(T-1)\cdot\beta\cdot\big(p\cdot W(3,2,2) + q\cdot W(3,1,2)\big),$$

$$G(2,1,2) = g\cdot\theta_0\big(Z_1 - B\cdot(RE(2) + max\{FiT - RE(2), 0\})\big),$$

$$Z_1 = Z(1,1),\quad B = \sum_{t=1}^{L}\beta^{t-1},$$

$$Z(1,1) = NRE_1 + \theta_0(L-1)\ \cdot\beta\cdot\big(p\cdot Z(2,2) + q\cdot Z(2,1)\big),$$

and $\theta_0(x)$ — Heaviside step function:

$$\theta_0(x) = \begin{cases} 0, & x \le 0; \\ 1, & x > 0. \end{cases}$$

ASSESSING RES POLICY ALTERNATIVES FOR RUSSIAN FEDERATION

In the previous section we have developed a model for defining current benefit in monetary units and other parameters of RES promotion policy, given its lifetime, year since introduction, inflation effect, current price of NRE source, efficiency of R&D expenses (decrease of the cost of installing RES) and the amount of feed-in-tariff (monetary incentives for clean energy use). Other parameters, that are determined for each year of policy realisation, are further possible paths for price and RES capacity, which will be achieved till the end of policy.

The model accounts for flexibility of energy users to shift from NRE to RES using pure economic rationale and the speed of new RES technology penetration. This instrument could be further used for many applications in energy policy design.

Official goal of Russian government in the area of RE is to achieve 4,5% of electricity generated from RES by the year 2020, which is translated to no less than 22 billion gWh, according to EBRD estimates. Considering this goal, our further research would concentrate on evaluation and comparing possible economic benefit of several policy options and scenarios for national economy up to year 2020. Our business-as-usual (BAU) scenario would assume RE costs are increased by 2% per year, and there is no FiT. RE cost increase is due to the effect of inflation, breaking even positive influence of new technology on the price of generation: R&D leads to decrease of RE costs while inflation increases it. As a result, RE costs are rising. We will check which set of joint parameters of two policy instruments — FiT and R&D subsidies — would lead to the best outcome, satisfying the "4.5% by 2020" strategic goal set by government.

In all subsequent scenarios (except for BAU) we assume that FiT is unchanged during policy lifetime and applied during 15 or 20 (depending on scenario) years after capacity was installed. Thus capacity owner might decide relying on guaranteed FiT to shift or not to shift to RES generation. Initial cost of RES capacity is defined by R&D efforts, therefore our model accounts for four factors, directly influencing capacity of owner's investment decision: guaranteed FiT amount and lifetime, current cost of capacity installation, inflation, and current NRE cost.

The options considered are as follows:

1. Investments decrease RE costs by 0% per year, high FiT during 15 years.

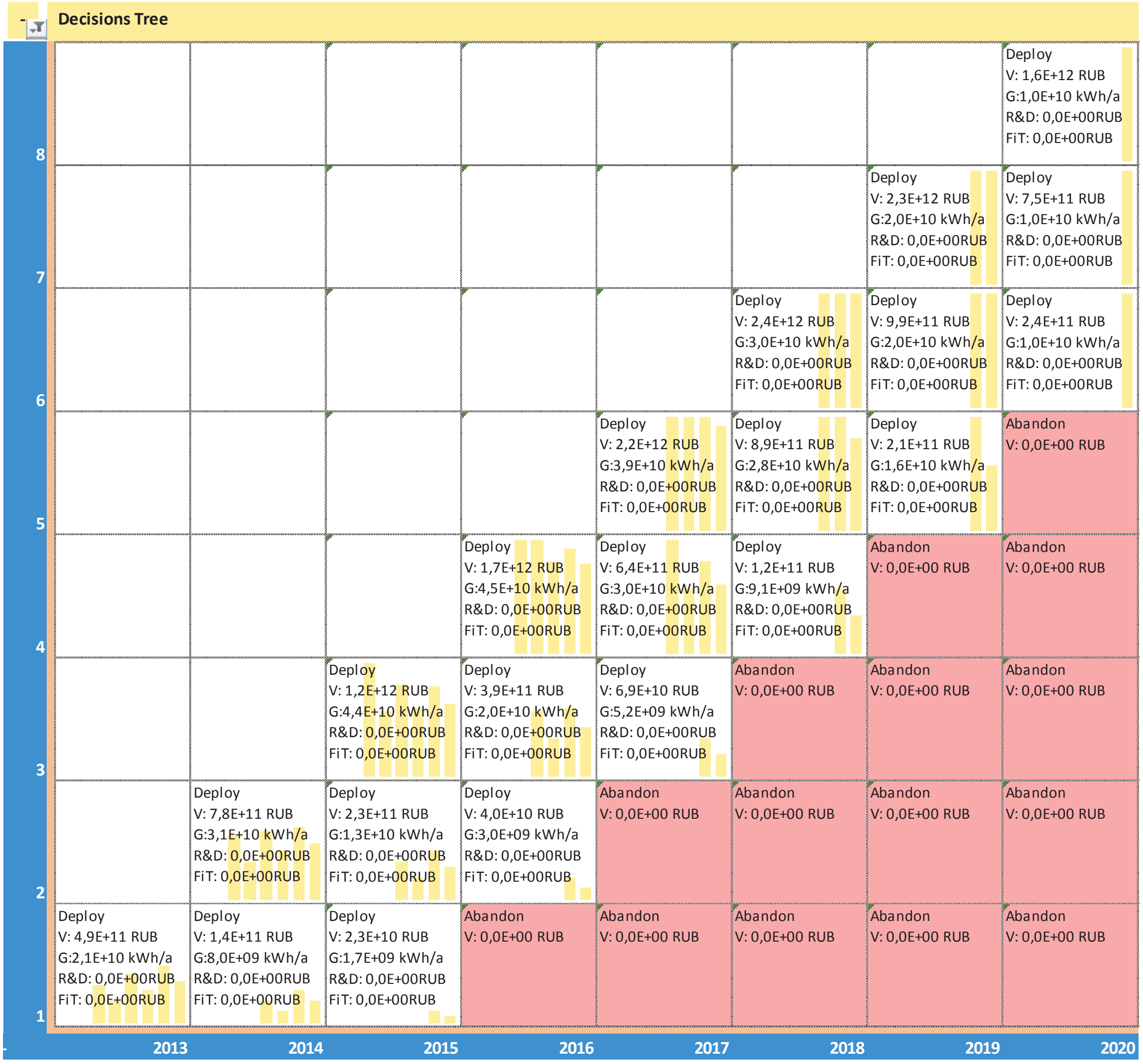


Figure 1.

2. Investments decrease RE costs by 0% per year, high FiT during 20 years.
3. Investments decrease RE costs by 2% per year, low FiT during 15 years.
4. Investments decrease RE costs by 2% per year, low FiT during 20 years.
5. Investments decrease RE costs by 2% per year, medium FiT during 15 years.
6. Investments decrease RE costs by 2% per year, medium FiT during 20 years.

Data regarding investments and current NRE price has been obtained from "The final report on the results of expert work on the issues of socio-economic strategy of Russia until 2020, Strategy 2020: New Growth Model — a new social policy" (2011), "Energy efficiency and energy development for the period 2013–2020" (2013), and website of Ministry of Energy of Russian Federation. Data regarding RE prices have been obtained from International Energy Agency resources. Other parameters are the assumptions.

RESULTS AND DISCUSSION

Simulation shows, that in BAU for the rational economic agents (homeowners, businesses) it is better to start deploying RES immediately under current NRE prices. But if these prices will hold to 2015, it will be more reasonable for owners to choose to abandon deployment and continue installing only if NRE prices would rise. Finally, in 2020 only 3 (out of 8 possible in our model) NRE levels would lead to RES capacities continue to be installed (see Figure 1).

Moreover, under any conditions additional RES capacities would achieve not more than 21 billion kWh/a in 2020, which is below policy goal of 4.5% RES generation in 2020. Total economic benefit generated in this scenario will be 490 billion RUB. Thus, our simulation shows that if government will not introduce enough economic incentives and R&D subsidies to promote RES, the only possible option would be to rely on C&C policies to achieve stated strategic goal.

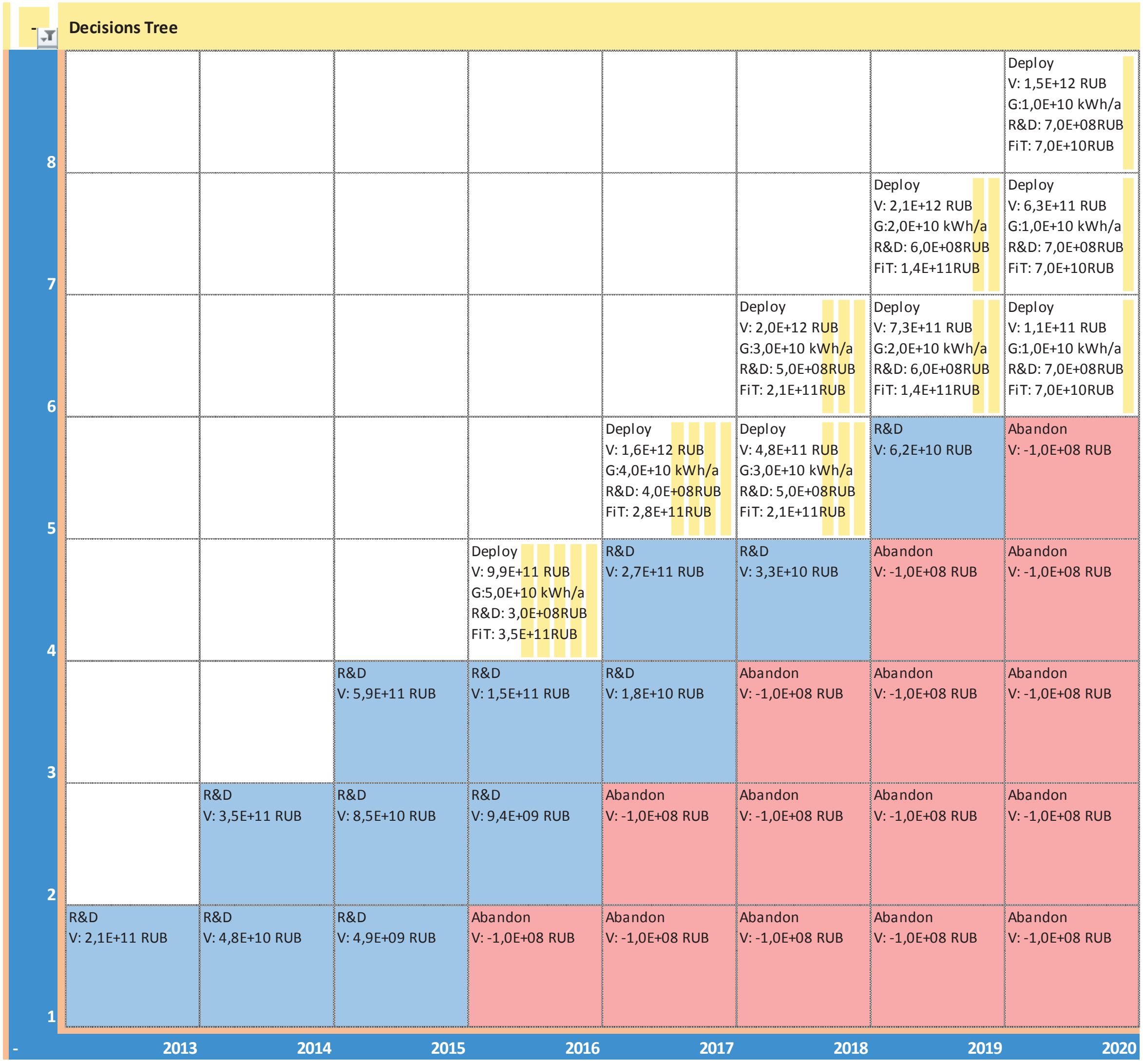


Figure 2.

Table below shows BAU inputs and outcomes in comparison with other 6 scenarios.

Our 6 scenarios incorporate both instruments (R&D and FiT) with different level of use. In the first scenario FiT is guaranteed during 15 year from any point of new RE installation. Tree on Figure 2 shows that in this case R&D would be continued till 2015 under any NRE market conditions. In 2016 the following variants are possible: deployment of achieved R&D or rejection of policy in total. In 1 state of 5 (very high NRE prices) there will be first installations of new capacities; otherwise, almost in every state of the NRE market government should continue to subsidize R&D and only in one state — very low price — it should completely abandon using RES and shift toward NRE. If NRE costs would

Table 1.

Scenario	R&D effect, % of yearly decrease of RES cost	FiT, RUB/kWh	FiT policy lifetime, years	R&D lifetime, years	Policy benefit, bn RUB	Final RES capacity, bn kWh/a
BAU	-2%	0	0	0	490	21
1	0%	7.0	15	2	990	50
2	0%	7.0	20	3	1800	50
3	2%	5.3	15	1	1200	54
4	2%	5.3	20	2	1900	58
5	2%	5.7	15	3	1600	50
6	2%	5.8	20	2	1700	58

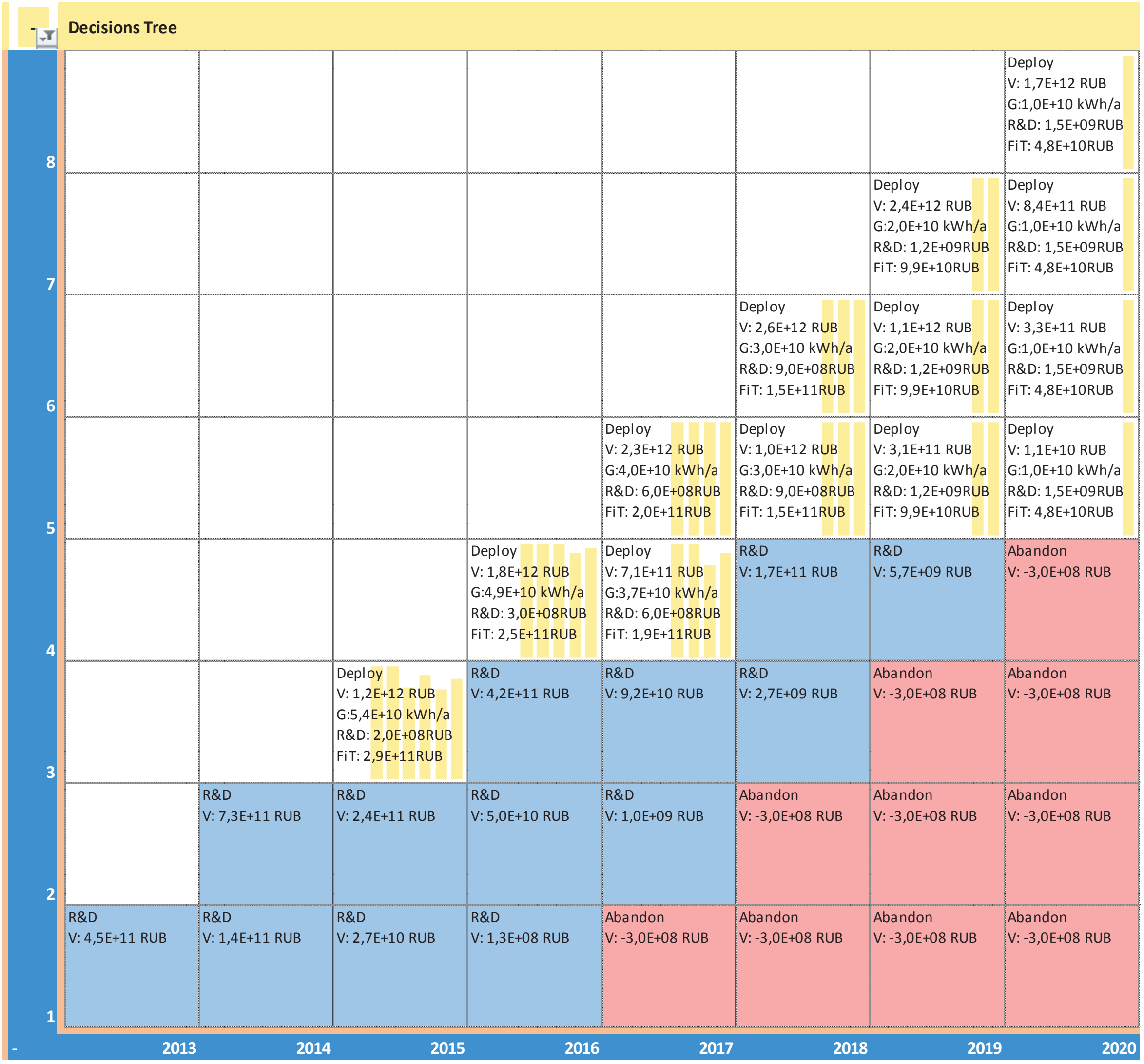


Figure 3.

continue to rise, it will be profitable to start deploying existing technology under FiT 7.00 RUB/kWh. With this tariff the agents will install about 50 billion kWh/a during policy lifetime, which is far above government goals, and total economic benefit for society will be 990 billion RUB.

Second scenario is also built on the assumption that R&D investments have no results. The only difference from the first one is that FiT is guaranteed during next 20 years, starting from any point of new RE installation. Extending policy lifetime only for five extra years almost doubles policy benefit from 990 to 1800 billion RUB, with new capacities volume remaining the same. Decision tree configuration also remains congruent to the scenario of 15-year high FiT.

In the third policy we have assumed that investments in R&D have very large effect and it is greater than inflation effect. As a result RE costs are decreased by 2% per year. Our results suggest that in this case depending on NRE price dynamics, installations could start as early as in 2015 (tree on Figure 3).

If NRE price would rise, it will be profitable to deploy RES technology and offer FiT, which is equal to 5.30 RUB/kWh in this scenario. Using this tariff economy would install about 54 billion kWh/a before 2020, which is higher than in scenario 2, and total economic benefit of the policy for the society will be 1200 billion RUB. From this result we can conclude, that while early introduction of new RES technology could bring more installations, the price for earlier adoption would be lower policy benefit even when FiT expenses are low for the government. Sometimes, even if from the point of view of individual agent it is rational to adopt current technology, for the economy as a whole more it is rational to abstain from immediate installations and continue investing in further decrease of RES installation cost. Further we would call such leeway left in benefit by early adoption "the productivity loss' of benefit.

Fourth scenario again bets on very large effect of R&D on RES cost, and low FiT is applied during

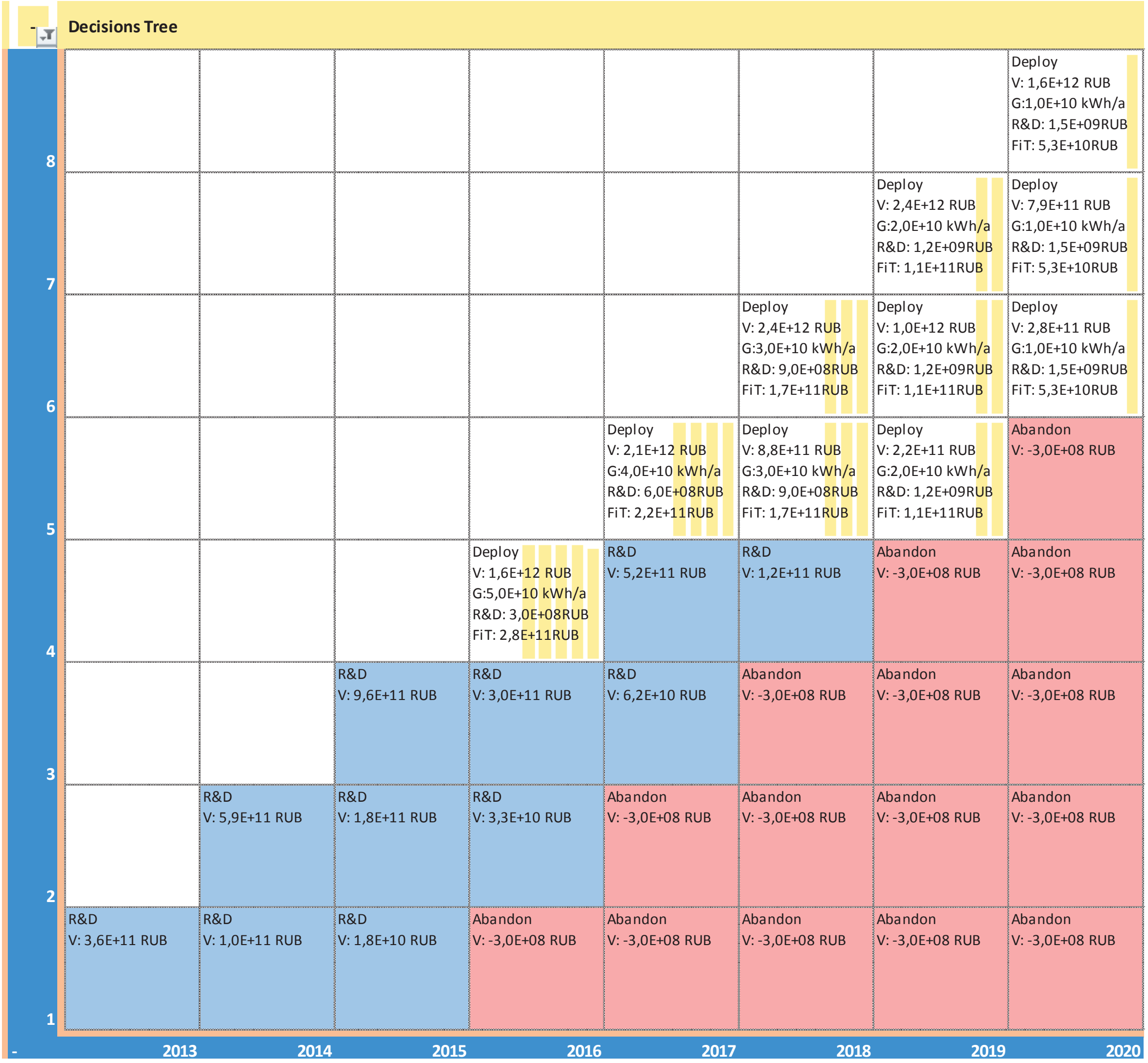


Figure 4.

prolonged 20-years period. First installation of newly born RES technology again appears no earlier than 2015. Extension of low FiT period by 5 years results in even higher volume of installations than in scenario 3 (58 gWh/a *vs*. 54 gWh/a), with policy benefit significantly higher than in BAU, and scenarios 1, 2 and 3–1900 billion RUB. That might be read as recommendation to policymaker, when confronting early adoption of fresh (and possibly suboptimal) RES technology, to provide extended period for low FiT policy, so that the market, forming comparatively higher penetration rate as an answer to enjoying more FiT, would install more and compensate the “productivity loss” of benefit with higher volume of capacities installed.

Finally, fifth and sixth scenarios were simulated to answer the following question: what is the scale of impact of FiT amount on policy benefit and penetration rate. Tree on Figure 4 shows that R&D should be continued at least till 2015. Applying “average” FiT incentive of 5.71 RUB/kWh is enough to stimulate installation of capacities close to scenario with high FiT an low R&D efficiency (scenarios 1 and 2), and total economic benefit for society overall will be 1600 billion RUB. Extending FiT period by five years (scenario 6) would give 100 billion RUB in policy benefit and 8 gWh/a capacities.

Comparing outcomes of scenarios 1–6 to BAU we have to note that FiT policy offers huge advantage over hands-off policy. The main recommendation is: if policymaker would like to increase market penetration of RE technology, he needs to increase FiT. In this case optimal points could be found using model, introduced in research. If policymaker aims to maximize revenue of policy, he may consider decreasing FiT, which would in turn decrease probability of technology diffusion. This is significant property of specified model: it takes into consideration conditions of successful market penetration as profitability for user of this technology. The model allows calibrating policy according to policymaker’s strategic goals.

REFERENCES

Ardente, F., Beccali, M., Cellura, M., Brano, V.L. (2008), *Energy performances and life cycle assessment of an Italian wind farm,* Renew Sust. Energy Rev. 12 (1), 200–217.

Bode-Greuel, K.M., Greuel, J.M., 2005. *Determining the value of drug development candidates and technology platforms.* Journal of Commercial Biotechnology, Vol 11, No 2, 155–170, January 2005.

Brennan, M.J., Schwartz E. S., 1985. *Evaluating Natural Resource Investments.* The Journal of Business, Vol. 58, No. 2 (April 1985), 135–157.

Caporal, A., Brandao, L.E.T., 2008. *Valuation of a Power Plant with the Real Options Approach.* Brazilian Business Review Vol. 5, No. 2, 103–120.

Cory, K., Couture, T., Kreycik, C., 2009. *Feed-in Tariff Policy: Design, Implementation, and RPS Policy Interactions.* National Renewable Energy Laboratory, Technical Report, March 2009.

Couture, T., Gagnon, Y., 2010. *An analysis of feed-in tariff remuneration models: Implications for renewable energy investment.* Energy Policy 38 (2010), 955–965.

Couture, T.D., Cory, K., Kreycik, C., Williams E., 2010. *A Policymaker's Guide to Feed-in Tariff Policy Design.* National Renewable Energy Laboratory, Technical Report, July 2010.

Davis, G., Owens, B., 2003. *Optimizing the Level of Renewable Electric R&D Expenditures Using Real Options Analysis.* National Renewable Energy Laboratory, February 2003.

Fan, Y., & Zhu, L. (2010). *A real options based model and its application to China's overseas oil investment decisions.* Energy Economics, 32 (3), 627–637.

Grace, R.C., Rickerson, W., Corfee, K., 2008. *California Feedin Tariff Design and Policy Options. California Energy Commission.* KEMA, Inc., September 2008.

Han, T.J.S., Lenos, T., 2004. *Strategic Investment. Real Options and Games.* Princeton University Press, 2004.

Hearps, P., McConnell, D., 2011. *Renewable Energy Technology Cost Review.* Melbourne Energy Institute, Technical Paper Series.

International Energy Agency, 2000. *Experience Curves for Energy Technology Policy.* Organisation for Economic Co-operation and Development.

International Energy Agency, 2005. *The Experience With Energy Efficiency Policies and Programmes in IEA Countries.* International Energy Agency, August 2005.

Kumbaroglu, G., Madlener R., Demirel, M., 2004. *A Real Options Evaluation Model for the Diffusion Prospects of New Renewable Power Generation Technologies.* Centre for Energy Policy and Economics, Working Paper No. 35, September 2004.

Kumbaroğlu, G., Madlener, R., & Demirel, M. (2008). *A real options evaluation model for the diffusion prospects of new renewable power generation technologies.* Energy Economics, 30 (4), 1882–1908.

Lee, S.C., Shih, L.H., 2010. *Renewable energy policy evaluation using real option model — The case of Taiwan.* Energy Economics 32 (2010), S67 — S78.

Mun, J., 2002. *Real Options Analysis. Tools and Techniques for Valuing Strategic Investments and Decisions.* John Wiley & Sons, Inc., Hoboken, New Jersey, 2002.

Mun, J., 2003. *Real Options Analysis Course. Business Cases and Software Applications.* John Wiley & Sons, Inc., Hoboken, New Jersey, 2003.

Reuter W. H. et al., 2011. *Investment in Wind Power & Pumped Storage in a Real Options Model — A Policy Analysis.* World Renewable Energy Congress 2011 — Sweden.

Ritzenhofen, I., Spinler, S., 2013. *Optimal design of feed-in-tariffs to stimulate renewable energy investments under regulatory uncertainty — a real options analysis.* WHU — Otto Beisheim School of Management, 2013.

Scott, V.V., 2010. *Disputed wind directions: Reinvigorating wind power development in Taiwan.* Energy for Sustainable Development 14 (2010), 22–34.

Siddiqui, A.S., Marnay, C., Wiser, R.H., 2005. *Real Options Valuation of US Federal Renewable Energy Research, Development, Demonstration, and Deployment.* Lawrence Berkeley National Laboratory, March 2005.

Siddiqui, A., & Fleten, S.— E. (2010). *How to proceed with competing alternative energy technologies: A real options analysis.* Energy Economics, 32 (4), 817–830. doi:10.1016/j.eneco.2009.12.007

Szolgayova, J., Fuss, S., & Obersteiner, M. (2008). *Assessing the effects of CO2 price caps on electricity investments — A real options analysis.* Energy Policy, 36 (10), 3974–3981. doi:10.1016/j.enpol.2008.07.006

Shafiee, S., Topal, E., Nehring, M., 2009. *Adjusted Real Option Valuation to Maximise Mining Project Value — A Case Study Using Century Mine.* Project Evaluation Conference, Melbourne, Vic, 21–22 April 2009.

Schumacher, K., Kohlhaas, M., 2007. *Learning-by-Doing in the Renewable Energy Equipment Industry or in Renewable Electricity Production — Why Does It Matter to Differentiate? A case study of Germany.* DIW Berlin.

Trang, N.T., Takezawa, Naoya and Takezawa, Nobuya, 2002. *Real Options and the Evaluation of Research and Development Projects in the Pharmaceutical Industry: A Case Study.* Journal of the Operations Research Society of Japan, Vol. 45, No. 4, December 2002.

Emiel van der Maaten, 2010. *Uncertainty, Real Option Valuation, and Policies toward a Sustainable Built Environment.* The Journal of Sustainable Real Estate Vol. 2, No. 1–2010.

Wang, K.M., Cheng, Y.J., 2012. *The Evolution of feed-in tariff policy in Taiwan.* Energy Strategy Reviews 1 (2012), 130–133.

Yang, M., Blyth, W., Bradley, R., Bunn D., Clarke C., Wilson, T., 2008. *Evaluating the power investment options with uncertainty in climate policy.* Energy Economics 30 (2008), 1933–1950.

Yeh, S., Rubin, E.S., 2012. *A review of uncertainties in technology experience curves.* Energy Economics 34 (2012), 762–771.

The final report on the results of expert work on the issues of socio-economic strategy of Russia until 2020 Strategy 2020: New Growth Model — a new social policy. Government of Russian Federation, 2011.

Energy efficiency and energy development for the period 2013–2020 years. Ministry of Energy, Russian Federation, 2013.

Greenhouse Gas Emission Scenarios for Russia and Rest of the World*

Alexey KOKORIN, Ph.D., Inna Gritsevich, Ph.D.
World Wildlife Fund (WWF Russia)
akokorin@wwf.ru

Dmitry GORDEEV
Gaidar Institute for Economic Policy, Moscow
gordeev@iet.ru

Abstract. The paper explores the reasons behind the evolution of judgments of the energy sector development and the resulting expansion of the variety of projection-based scenarios both for Russia and globally. It shows that there are two types of scenarios depending on the degree of climatic risks accounting: zero and imperative, the latter requiring an abrupt reduction of emissions. The difference is resolved by developing scenarios that optimize overall costs of emission reduction and adaptation to the negative effects. Development of such scenarios involves substantial difficulties, so it is unlikely that Russia's and other countries' targets analyzed in the paper will be significantly changed before 2020. Calculations on the TIMES international model used in Russia for the first time showed that economically optimal development of the country's energy sector leads to the stabilization of CO_2 emission at 75% of the 1990 level, and to further reduction to 70% by 2030. Reduction beyond these values requires additional costs, for example, emission charges. However, in Russia there is evidence of non-optimal development in the recent years, leading to the emission growth.

Аннотация. Рассмотрены причины изменения взглядов на развитие энергетики и расширения спектра прогностических сценариев для России и мира. Показано, что сценарии делятся на два типа по степени учета климатических рисков: нулевой или императивный, требующий резкого снижения выбросов. Противоречие разрешается созданием сценариев, оптимизирующих суммарные затраты на снижение выбросов и адаптацию к негативным явлениям. Их построение связано с трудностями, поэтому до 2020 г. маловероятно кардинальное изменение рассмотренных в работе целей России и других стран. Впервые проведенные в России расчеты по международной модели TIMES показали, что экономически оптимальное развитие энергетики страны приводит к стабилизации выбросов CO_2 на уровне 75% от 1990 г., а к 2030 г.— их снижению до уровня 70%. Дальнейшее снижение требует специальных затрат, например, платежей за выбросы. Однако есть признаки экономически неоптимального развития России в последние годы, что ведет к росту выбросов.

Key words: Greenhouse gas emissions, scenarios, Russia, climatic risks.

INTRODUCTION

During the last three years the vision of global energy sector development and, more generally, global economic development has changed quite significantly. The variety of development scenarios for the next 20–40 years has considerably changed and expanded for many countries, because the old concepts fail to account new financial and economic realities and to answer emerging questions. Apparently, translation of development scenarios into greenhouse gas (GHG) emission dynamics curves shows that these can differ fundamentally, with some of them showing growth, while others demonstrating abrupt reduction. What reasons urged development of new scenarios? Does the difference mean that some scenarios are correct, while the others are wrong, and what might be the "truth" in between? This is the first group of issues discussed in this paper.

In 2012, international climate negotiations of 195 members of the UN Framework Convention on Climate Change (UN FCCC) entered a new phase. The focus of attention has shifted from the Kyoto Protocol to a new climate agreement that would come into force in 2020. Preparation of this agreement is to be accomplished by late 2015. Intrinsically, it is a

* Сценарии выбросов парниковых газов в России и в мире в целом

financial and economic agreement that determines how GHG emissions by developing countries are to be limited with financial assistance provided by developed countries both for emission control and adaptation to the negative consequences of anthropogenic climate change. The second part of this paper elaborates on Russia's prospective commitments for GHG control and reduction.

MAJOR DRIVERS BEHIND MODIFICATION AND EXPANSION OF THE VARIETY OF DEVELOPMENT SCENARIOS

The global economic crisis became the first cause of the change. Economic growth of 2003–2008 was accompanied by devastating hydrocarbons price growth; however, the crisis did not bring down prices of all raw material resources, it rather determined their wild fluctuations which persist until now. Recovering from the crisis, many countries saw that their old ideas of long-term sustainable growth were incorrect, and re-evaluated projected development rates for the coming decades. Russia was one of these.

Another factor deals with a considerable modification of the fuel and energy balance. A good many countries have made use of the crisis realities to promote transition to low-carbon development, i. e. development based on new technologies with minimal or zero CO_2 emissions. The measures they took included aggressive promotion of renewable energy sources; electricity, heat, and motor fuel savings, etc. At the same time, gas production from alternative sources showed rapid growth spurred by high prices, which made these sources economically viable. These changes are pertinent to Russia as well, both in the context of improving energy efficiency and employing renewable energy sources and in the context of changing demand for our export products — primarily gas.

The goals pursued by these countries were diverse: a wish to reduce dependence on imported energy carriers, diversification of energy sources, creation of jobs, promotion of their own technologies; but apart from these some countries really sought to reduce the anthropogenic interference with the climate system, in which the key role belongs to CO_2 emissions and the enhancement of the greenhouse effect, as was underlined by Roshydromet (2008) and IPCC (2007).

The third factor is insistent demands by environmental experts, international community, and the most vulnerable countries to reduce greenhouse gas emission to the level that would guarantee that climate change is kept within relatively safe limits. Evaluation of the safe level is not at all an easy task. Today, the "safe level" is assumed at 2°C increase of the global near-surface air temperature over the pre-industrial average. According to the IPCC (2007), as well as Roshydromet (2008), exceeding this 2°C rise limit will result in enhancement of droughts and other dangerous events. However, for the most vulnerable countries, in particular, for small island states, the "safe level" is much stiffer: 1.5°C. Despite the conventionality of this parameter (because not mean air temperature, but rather its surging and dangerous hydrometeorological events, rising sea level, etc. are responsible for the damage), it was taken as a basis and is the UN-accepted target[1], serving as the reference for calculating the necessary reduction of the global emission.

There are many subtleties to this calculation, and besides, it can only be made in terms of probability. According to the IPCC estimates, it would be necessary to attain CO_2 stabilization at 450 ppm (with current concentration of about 400 ppm), and the growth of other anthropogenic gases is not to exceed 100 ppm in CO_2 equivalent, to give at least 10% probability of not exceeding 2°C; and this would require 50% reduction of the global emission by 2050. According to IPCC (2007), to give 30–50% probability, and also to preserve some possibility of keeping the air temperature increase below 1.5°C, 80% reduction is needed by the middle of this century.

It is important to make a point that there is a wide uncertainty about response time range, in which climate will be reacting to the growing concentration of greenhouse gases in the atmosphere[2]. Besides, the observed effects are a combination of decades-long natural variations and the entire variety of anthropogenic impacts, of which CO_2 emission is only the main one (very important are particulate matter and soot emissions: while the former cools down the atmosphere, the latter warms it up). For this reason one can hardly be dogmatic about feasibility or impracticability of a certain temperature target. At this point, all targets are to be kept in mind and all possibilities need to be explored.

[1] All UN FCCC member-states, including each and every large country, officially adopted 2 °C as a target and formalized it in UN documents. See Cancun agreements, December 2010, and Durban platform, December 2011, www.unfccc.int

[2] Response of the world ocean to the anthropogenic impact on the atmosphere is very much delayed and uncertain. Achieving a balance may take decades and even hundreds of years, especially for high stabilization levels of 600–700 ppm and beyond. In particular, current aggregate concentration of CO_2 and other anthropogenic greenhouse gases in CO_2 equivalent equal to 450–500 ppm. This concentration correlates to the temperature rise up to a balanced state of approximately 2.5 °C above the pre-industrial level. However, the observed effect is three times lower: the temperature increase is 0.8 °C (see Roshydromet (2008) vol.1 pp. 93–97).

Therefore, back in 2008 G8 adopted general recommendations for at least 50% reduction of global greenhouse gas emissions by mid-XXI century. The G8 Declaration (2009) for leading developed countries confirmed reduction by at least 80%. Such decision is sort of an order for 50% and 80% reduction scenarios for Russia.

The fourth factor deals with revised opinions on the nuclear energy. The Fukushima accident not only affected Japan's energy policy (although not as much as it seemed two years ago), it accelerated decision-making in a number of other countries. It became clearer, how high the price of nuclear energy is, i. e. of costly safety measures, which become increasingly larger in number. According to the recent International Energy Agency (IEA) WEO (2012), in the context of the entire global energy the nuclear sector is perceived as a relatively small one with a very limited growth potential, primarily existing in China, India, and Russia. And development of nuclear energy provided by fast reactors is at best viewed as a matter of very distant future, not least because nearly all the leading economies have rejected the idea (see IEA *Energy Technology Perspectives* (2012)).

THREE TYPES OF SCENARIOS AS THREE STEPS TO LONG-TERM PROJECTIONS OF THE ECONOMY'S RESPONSE TO CLIMATE CHANGE

The above factors inspired the International Energy Agency (IEA), other international and national agencies, large business and even environmental organizations to develop new scenarios. IEA and other organizations develop two types of scenarios, both global and for individual countries, including Russia.

The first type of scenarios — "classic" scenarios — describe the most expected energy and economic development based on ***current*** ideas of business and governance. These scenarios implement policies and innovations that are within the current development paradigm. This paradigm suggests low-carbon development, but no concrete emission control targets. CO_2 is energy efficiency and renewable energy use indicator, rather than a specific goal. Various CO_2 emission charges are often included in the models too, if they help attain primary goals of energy efficiency, renewables or employment. In this case emission charges obviously do not hamper economic development.

Authors of these models realize both the difficulties associated with long-term forecasting and the limitations of today's vision of future, so normally they consider the next 25–30 years: until 2030 or 2040. Estimations for 2050 are also made, but mostly as an interesting research exercise.

Of global scenarios, those better known and widely used include New Policy Scenario of the IEA WEO (2012), which incorporates the latest optimistic vision of the natural gas use presented by IEA before in the IEA Special Report (2011). Regularly updated BP projections (2012) can also be mentioned. ERIRAS-AC (2013) is a contribution by Russian experts, who published their review of the post-crisis global development until 2040. All these scenarios promise smooth growth of global energy-related CO_2 emission for the next 20–25 years, and all of them predict practically the same values: +20 — +25%, see Table 1.

There are new scenarios for Russia as well. In late 2011 IEA published IEA Outlook for Russian Energy (2011) with detailed estimates corresponding to the global "new policy" scenario. In spring 2012, Russian experts made their step forward. Energy Research Institute of the Russian Academy of Science (ERIRAS) published a projection of Russia's energy sector development until 2035 (ERIRAS-REA (2012)). In ERIRAS-AC (2013) the projection horizon was extended to 2040 and supplemented with the latest data on non-conventional gas and oil sources. For the years to come, these projections are likely to become the major source for official scenarios of the energy sector development. In fact, this effort was similar to the IEA's "new policy" scenario for Russia, but based on a better knowledge of Russia's realities and on the opinions of ERIRAS experts and experts of the Analytical Center of Russian government. ERIRAS also has preliminary estimates for Russia for 2050, see Veselov *et al.* (2012).

In accordance with NIR RF (2013), in 2011[3] Russia's CO_2 emission was 32.6% below the 1990 level, cumulative energy-related GHG emission was 29.3% below (with energy-related CO_2 emission 34.2% below), and cumulative GHG emission 30.8% below that level (UN FCCC normally compares emissions to the 1990 baselines, and Russia's international commitments are estimated that way, too). Let us point out, that these values refer exactly to emissions. For our country it is very important to take account of the role played by forestry (human-induced CO_2 emission and absorption by forests). UN FCCC and UN national commitments do not take account of all forests, but only of so-called "managed" forests, which constitute around 85% of all forests in

[3] In compliance with the world practice and UN FCCC procedures, data for 2012 will be presented in April 2014.

Table 1. "Classic" scenarios of global and Russian energy sector development.

Type of scenario	Global (time period, growth of energy-related CO_2 emission)	Russia (projection horizon, energy-related CO_2 emission compared to 1990)
Scenarios based on ***current*** view of governance and business	IEA WEO (2012) "New Policy Scenario": 2010–2035, +23% BP (2012): 2010–2030, +25% ERIRAS-AC (2013): 2010–2035, +20%; 2010–2050, +25%	IEA Outlook for Russian Energy (2011) "New Policy": 2035, –14% ERARAS-REA (2012): 2035, –15% Veselov *et al.* (2012): 2050, range from +5 to –25% Bashmakov (2009) and Bashmakov & Myshak (2013): 2050, range from 0 to –25% McKinsey (2009): 2030, –27%*

** This research is not a simulative projection of the economically optimal development, but rather an assessment of the potential and economic viability of individual measures accompanied by a cost curve. The given numerical parameter reflects implementation of all economically viable measures for all GHG emissions.*

the Russian Federation. According to NIR RF (2013), now they are a large net absorber of CO_2, while back in 1990 a reverse situation was observed: a small net emission. As a result, in 2011 overall emission of all greenhouse gases with an account of net absorption of CO_2 by forests was 50.8% below the 1990 level. However, economic and energy scenarios do not include "managed" forests, so one has to start out from the energy-related CO_2 emission level, see Table 1.

Therefore, "classic" scenarios (first type scenarios), covering the period 2011–2035, predict Russia's energy-related emission growth equal to the lower boundary of the global emission growth range: around 20% (or by 10–15 percentage points from the 1990 level).

The second type of scenarios is based on the ***prospective*** development paradigm and the need to attain a certain goal. As a rule, such opinions are already today's views of the advanced and environmentally conscious part of the international community, yet are not so far shared by officials and the business community. These scenarios assume that prospective developments will determine the need for setting this goal. Models are further used to figure out how to best attain this goal from the economic point of view. And the goal itself is *a priori* assumed to be imperative. Such goal may be transition to own energy sources (rejection of import), complete transition to renewable energy, or achieving a GHG emission target. As a rule, this is an analysis of possibilities to cut CO_2 emission by 50–80% by 2050.

IEA WEO (2012) presents a scenario "450 ppm" which demonstrates how the global energy sector can be developing so that the emission level in 2050 is 50% below the current level. These scenarios analyze technical and economic attainability of a particular goal and assess additional investment demand for the transition to this development trajectory, see Table 2.

WWF International & Ecofys (2011) arrived at conclusion that by 2050 all the energy in the whole world can be produced from renewable energy sources. GP & EREC (2010) came up with a more moderate estimate of the production technology potential: 80% of primary energy consumption will be produced from renewable energy sources by 2050. For Russia, their estimate is 57% from renewable energy by 2050, and 70% CO_2 emission reduction in 2005–2050, as published in GP & EREC (2009). Generally, similar figures for Russia are presented in the recent IEA WEO (2012), where the "450 ppm" scenario shows 47% reduction in 2035 as compared to 1990, see Table 2.

In other words, attainability of abrupt emission decline has been demonstrated. However, this result is not being employed by the developers of "classic" scenarios. The curves in Fig. 1 drift apart. And yet there is no miscalculation on any side. The reason is taking diametrically opposite account of the climate factor. The first type scenarios view the climate risk as negligible. In such scenarios (for example, those by IEA), CO_2 emission charges, like, say, in the EU or in China, are merely an additional instrument to address such challenges as energy efficiency improvement, introduction of certain technologies, or development of renewable energy. These charges constitute no additional burden on the economy, so the economy develops without making "deductions" to address climate issues.

The second type scenarios take the climatic risk as an imperative goal: emissions are to be abruptly cut despite economic losses or disproportions in energy mix. CO_2 charges are forcefully introduced in all countries, after a certain moment becoming a burden on the economy, that has to make considerable and even huge "deductions" for the sake of emission reduction and addressing the climate issues.

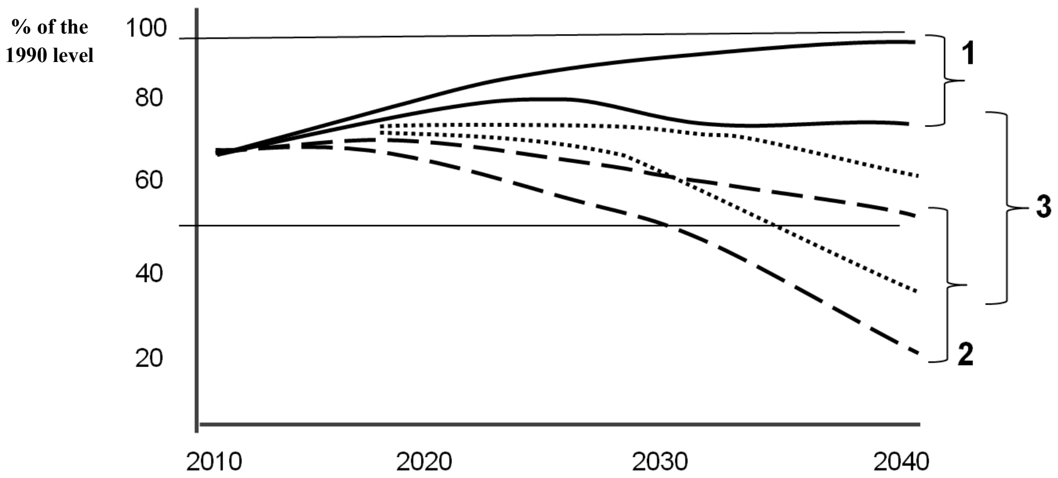
Table 2. Global and Russian energy sector development scenarios that implement *a priori* set goals for emission reduction.

Type of scenario	Global (time period, reduction of energy-related CO_2 emission)	Russia (projection horizon, energy-related CO_2 emission compared to 1990)
Scenarios that implement *a priori* set goals for GHG emission reduction	Attainability of goal –50% by 2050 IEA WEO (2012) "450 ppm scenario": 2010–2035, –25% GEA (2012): 2010–2035, –17% Attainability of goal –80% or lower for 2000–2050 was presented by WWF International & Ecofys (2011); Deng *et.al.* (2012) and GP & EREC (2010)	Attainability of goal –50% by 2050. IEA WEO (2012) "450 ppm scenario": 1990–2035, –47% IEP-WWF, see Fig. 4 below: 1990–2050, –50% Attainability of goals –80% or lower for 2000–2050 was presented by GP & EREC (2009)

Discussion of which type of scenarios is "truer" doesn't seem to make sense. Both types are accurate to the extent their assumptions of the importance of the climatic risk are correct. In the first case, damage caused by climate change is negligible, while in the second it is so huge, that prevention becomes an imperative goal.

From the economic point of view, there is a need for the third type scenarios: elaboration of a long-term economic development strategy to minimize the ***overall costs*** of three types of action: GHG emission reduction; adaptation to the new climate conditions; and combating damage caused by climate change. Obviously, positive effects of climate change also need to be taken into account, although we are yet to learn how to make use of them.

It is important to estimate losses and compare them with emission reduction costs, see Fig. 2. IPCC has been for a long time trying to do so, collecting data on the damage, risks, insurance options, and possibilities to prevent disastrous losses. IPCC (2007) Fourth Assessment Report provides a large bulk of information, even more to be presented in the next (Fifth) Assessment Report to be released in 2014. However, so far not much comes out of the attempts to adequately compare the damage with emission reduction costs. A good try was made in *The Economics of Climate Change* (2006), which contains an absolutely dramatic calculation of how GDP of individual groups of countries will be going down depending on the climate scenarios, see also Kokorin *et.al.* (2009). However, this report was of such a



1 — range of projections based on "classic" scenarios: estimating the economic optimal development of the economy exclusive of the need for special reduction of the CO_2 emission

2 — range of projections based on the second type scenarios: formulating an imperative goal of mandatory reduction of CO_2 emission

3 — prospective scenarios of the third type, where an optimal strategy is selected to minimize overall costs of CO_2 emission reduction, the costs of adaptation to negative climate conditions, and the damage caused by climate change.

Figure 1. Schematic plot of Russia's CO_2 emission for three types of scenarios (excl. net CO_2 absorption by forests).

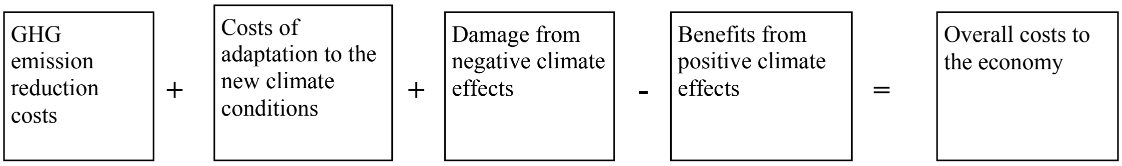


Figure 2. Calculation scheme to minimize the overall costs in the third type scenarios.

general nature, that it was rather an illustration to attract attention, than an appeal for concrete economic action. A research by Potsdam Climate Institute published in 2013 appears to be a much more serious effort, having integrated the entire available information on the prospective damage depending on the global temperature growth. However, this was accomplished for only three, obviously most vulnerable, world regions: Africa to the south of Sahara, South-East Asia, and South Asia, see Schellnhuber *et.al.* (2013).

Starting from a certain limit, net impact of climate change (balance of negative and positive effects) becomes negative even for northern countries. We may have already approached this limit. Evolution of average annual temperature in the territory of Russia between 1976 and 2011 accounts for nearly 1.5^0C. We now can see a more "nervous' climate with a large number of temperature jerks (heat waves and "unexpected" devastating frosts), more prominent precipitation (rain showers, snowfalls and snowstorms), strong winds, droughts, and floods. The costs of air conditioning tend to exceed heating cost savings, even if the latter were obtained. Damage caused by devastating floods and deluges exceeds potential benefits that might be brought by a longer vegetation period and higher crops yield. Higher temperatures and weaker ice in the North are by far "compensated" by permafrost melting, increasing number of snowstorms and gales, strong bank and shoreline erosion, etc.

A detailed status report and an analysis of the available information to assess the damage were accomplished in 2011 by a team of Russian climate experts and economists in *Macroeconomic Impacts* (2011). Somewhat more detailed summaries of the negative and positive effects for the coming 10–30 years were presented by WWF Russia for 11 subjects of the Russian Federation located in the Russian Arctic and the Far East in Kokorin *et.al.* (2013). Regretfully, the information is presented as text descriptions of the prospective problems, and is difficult to translate into numerical parameters, let alone in the monetary terms. There are quite a few objective reasons for that.

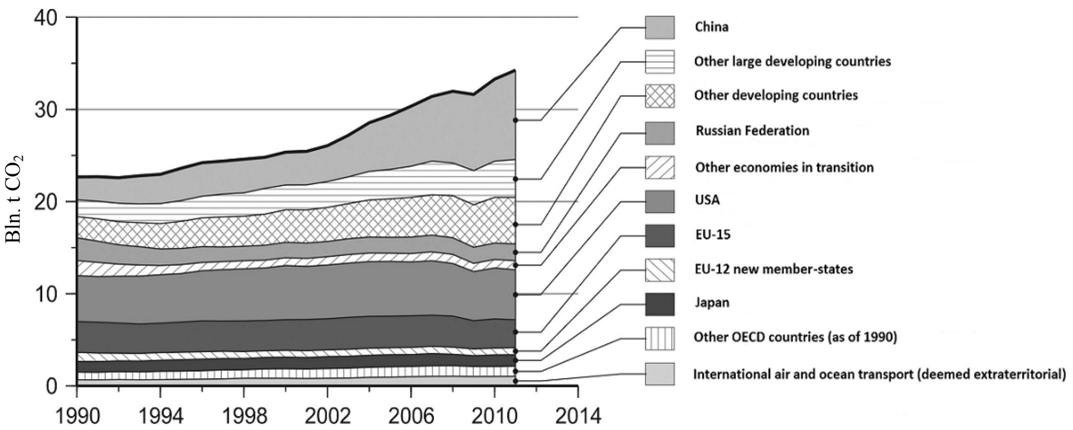
In the first place, there is a need for very long-term (30–50 years and beyond) climate and economic projections and plans. Inertia of the climate system is very significant, and our today's action determines the situation to be faced in 30–50 years' time, no sooner than that. However, beyond that time the difference may be very substantial, according to the recent Special Report of the Intergovernmental Panel on Climate Change (2012) on extreme weather events. For example, in 50–60 years' time devastating heat waves may occur either once every 3 or every 7 years. Obviously, both damage and preparation (adaptation) for diverse frequency of weather events will demand diverse investment. Prospective incongruity of climate projections that are based on different emission scenarios can be clearly seen on the interactive map presented on the website of Voeikov Main Geophysical Observatory.

So long planning period is not only about figuring out what is cheaper: to pay three times less today or three times more 40 years later. It is also a new lifestyle and a new economic guidance. So far, many countries, including Russia, are not used to being seriously conscious about such distant future.

Secondly, the globality of the problem. Emission reduction in an individual country is no solution. Only emission reduction by all countries can mitigate climate change. Therefore, there should be a very complex cooperation between the largest economies, primarily China, India, and the U.S., to promote emission reduction in "equal" shares. Quotation marks that enclose the word "equal" are not incidental; they suggest a balance to reflect different levels of economic development and the differences in the economies. This is exactly an issue that is being discussed by the UN FCCC, which in late 2011 came up with a decision that the corresponding new agreement was to come into force only in 2020[4]. This rescheduling reflects objective difficulties, primarily lack of accurate calculations of damage versus emission reduction costs for the largest economies.

Thirdly, climate change is a combination of anthropogenic impact and long-term natural variations, including possible human interference with these variations. This means that global surface air

[4] For UN FCCC documents see www.unfccc.int. For a review of the course of negotiations see www.wwf.ru/climate.



Source: data from *Trends in Global CO_2 Emissions, 2012 Report* (2012).

Figure 3. CO_2 emission from energy and cement production, which is the largest (~70%), but not the only, component of global anthropogenic emission of greenhouse gases.

temperature growth is not smooth, intermitting or speeding up at times. The same essentially refers to the number and intensity of dangerous events[5]. Politicians and incompetent people might then have a wrong impression that the global warming is over, which obviously does not encourage making long-term and costly decisions.

And finally, there is a fundamental problem dealing with complete account of damage. One can estimate the costs of shifting the entire population of a small island state to, say, Australia, including the costs of moving and settling, creation of jobs and infrastructure. But can one assess the costs of extinct wildlife of this island? This problem is directly related to the long-discussed issue of payments for ecosystem services and nature preservation.

Nevertheless, according to the opinion of economists, in particular those participating in the preparation of the next (Fifth) IPCC Assessment Report, there is no other way. Let it be excluding ecosystem services and only for an incomplete set of dangerous events, but the damage is to be estimated for all leading economies and compared to their emission reduction costs. Otherwise costly scenarios, for example, "450 ppm" by IEA or complete transition to renewable energy sources are hanged in the air and treated extremely skeptically by the business community and officials.

INTERNATIONAL COMMITMENTS FOR GREENHOUSE GAS EMISSION REDUCTION

In the 2000-s, the situation with global GHG emission was different from that at the moment of signing UN FCCC and developing the Kyoto Protocol. At that point the main role was played by the developed countries, whereas now the largest developing countries, primarily China and India, are responsible for nearly entire global emission growth, see Fig. 3. According to Agibalov & Kokorin (2010), this has given birth to a new concept of global action, where emission is cut by all countries, but developed economies provide financial and technical assistance to the developing states. This concept backs development of a new climate agreement in the UN, which is to be adopted in late 2015 and to come into force in 2020.

Based on the national situations and proposals for the global agreement, 5 groups of countries can be identified, whose opinions, for the sake of brevity, are presented in a summary Table 3.

Incongruity of opinions presented in Table 3 is so substantial, that a fast consensus is unlikely. Nevertheless, it is very important for Russia to formulate its own targets for the expected term of the new UN FCCC agreement, i. e. for 2020–2030.

POSSIBLE RUSSIA'S GHG TARGETS FOR 2020 AND 2030

Under the circumstances, it doesn't seem to make much sense to discuss the level of GHG emission in our country in 2050 or beyond. A declaration that emission cannot be abruptly reduced would be equally strange, opposing Russia to the developed countries and exposing it to criticism by environmental experts. Therefore, no wonder that in the G8 Declaration (2009) Russia did not object to the common recommendation on emissions reduction: global by 50% and those by developed countries by 80%. However, A. V. Dvorkovich, the Russian Sherpa, pointed out that the range was very wide for Rus-

[5] See, for example, materials of Roshydromet's monthly electronic bulletin "Climate Change" at www.global-climate-change.ru or www.meteorf.ru.

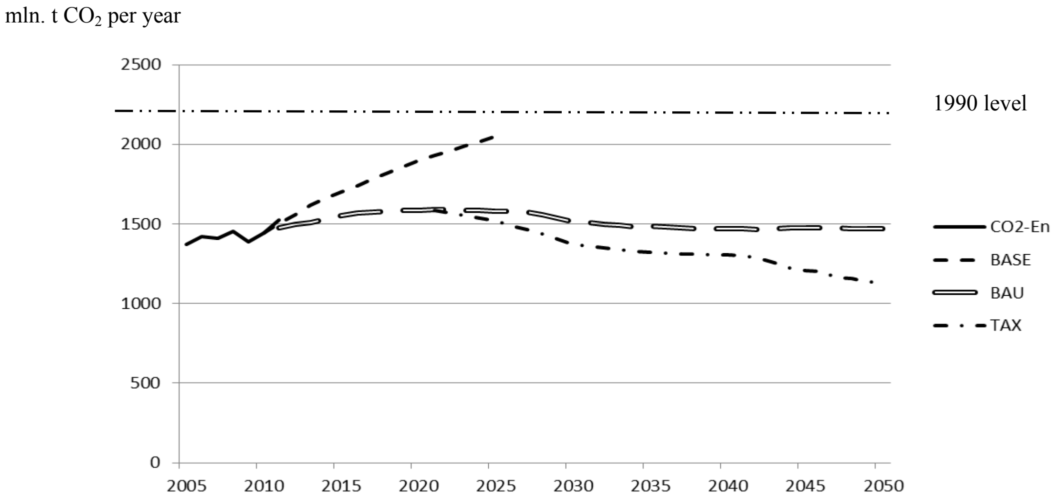
Table 3. Attitudes of various countries to long-term commitments for GHG emission reduction.

Countries	National situations	Proposals on emission reduction commitments
Developed countries, including Russia	In most countries, emissions are already declining (new technologies introduction rates are ahead of GDP growth). These countries have low-carbon development scenarios until 2030 and 2050, which assume 80% or more emission reduction. However, these scenarios assume certain external prerequisites, including low-carbon development of developing economies, primarily China and India. Russia is undergoing a slow emission growth trend, which is to be replaced with stabilization, as the country develops.	It is important, as soon as practicable, to transit from hampering the growth of global emission to the emission reduction in absolute figures. Global emission peak is to be overcome before 2020. General commitment by all countries to halve global emission by 2050 (compared to the 1990, 2000, or 2005 levels, different countries use different years). The majority of developed countries are prepared to cut their emissions by 80% by 2050.
China and India	Emissions are growing very fast. These countries are responsible for 80% or more of the global emission growth. They lack optimized economic development scenarios, which would guarantee 50% reduction of the global emission by 2050 (even if developed countries bring down their emissions by 80%). Until mid-2020s, these countries can see no way of reining in the growing emission (production growth is by far ahead of the introduction of new technologies). India's priority is combating poverty. Only when this challenge has been addressed, the country will be prepared to put low-carbon development first.	Vigorously opposed to any numerical parameters of the global emission, including 50% reduction by 2050 or setting any year as the emission peak. For 2020, agree to make emission reduction commitments in specific units (2–3% annual reduction of emission per unit of GDP), but not for emission stabilization. India firmly couples its commitments with external financial aid.
Brazil, South Africa, Mexico, South Korea, Indonesia, etc.	Emissions are growing, but there are economic development projections and scenarios that will lead to the stabilization of emissions by these countries in early 2020-s (transition to low-carbon development). For Brazil and Indonesia, emission dynamics are strongly determined by external aid.	Occupy an intermediary position between developed countries and China and India. Are prepared to join up the common commitment by all countries for 50% reduction of the global emission by 2050. Willing to make commitments in specific units that will lead to their emission stabilization by 2020.
Saudi Arabia, Qatar, United Arab Emirates, Kuwait, etc.	Extremely high per capita emission (yet not high in absolute terms). Fearing that other countries' low-carbon development may bring oil demand down.	Opposed to any numerical emission reduction commitments for states that do not have the status of developed countries in the UN FCCC (i. e. for themselves).
Nearly 100 least developed island/ highland, etc. states	Low emissions. Regardless of the economic development dynamics or type, these countries provide no impact on the global emission. Are particularly vulnerable to climate change.	Advocate radical and immediate reduction of the global greenhouse gas emission.

sia: in 2050 emission could be 20 or 60% below the 1990 level.

On the other hand, of course, there is a need for GHG assessments and targets for the years to come. On the international level, GHG emissions have become an indicator of a country's development, energy efficiency, and environmental policy. No development projections can ignore GHG emission levels. This is pertinent to Russia as well; in late March 2013 Russian Prime Minister signed a new Social and Economic Development Projection for the Russian Federation until 2030 (2013), which was prepared by the RF Ministry of Economic Development (MED). This document outlines the following emission trends: in the 2010-s GHG emission will be slowly growing to reach 75% of the 1990 level by 2020 and then drop to 70% of the 1990 level by 2030. As of 2011, the emission stayed at 69%, for details see the discussion of Table 1 above; see also NIR RF (2013). This projection excludes CO_2 absorption by forests and deals only with GHG emission in the Russian economy.

However, in the above projection GHG parameters are sort of separate from the presented macroeconomic scenarios: conservative, innovative, and accelerated. No GHG emission estimation by scenarios was done prior to the projection development. To a certain extent, one may presume that GHG emission (same as energy consumption) is less dependent on the implemented scenario, than other pa-



CO_2-En — Russian energy-sector CO_2 emission in 2005–2011
BASE — no-new-technologies scenario (4% annual GDP growth)
BAU — economically optimal introduction of new technologies; correlates to the innovative scenario by MED for 2030 (4% GDP annual growth). A first type scenario (see Table 1), which does not set any specific targets for GHG emission reduction
TAX — a BAU scenario with additional introduction of CO_2 charges since 2020, rising from USD 15 to 80 per ton. A second type scenario (see Table 2), which sets a special emission reduction target: 50% of the 1990 level by 2050.

Figure 4. Evolution of Russian CO_2 energy-related emission by scenarios; calculations by IEP using the TIMES model.

rameters, including GDP growth rates, consumption of certain products, etc. In the innovative scenario, GDP growth is higher, but since energy efficiency technologies are introduced faster, overall emission dynamics may be quite close to the conservative scenario. Nevertheless, exploring the correlation of GHG emission dynamics with the development of Russia's entire economy, as well as of individual sectors, and further with individual measures is definitely an important task.

Setting this task is being discussed by the federal government in the context of setting a national GHG target, which, in its turn, is required for detailing our participation in the new UN FCCC international agreement. At the moment of this paper submission (late June 2013), all federal ministries have agreed to the draft government decree specifying the 2020 target as keeping the emission at 75% of the 1990 level. The draft further stipulates that the above target needs to be broken down by sectors of economy.

The authors have estimated Russia's CO_2 emission, and this effort became one of the first steps to addressing the goal. The Gaidar Institute for Economic Policy (IEP) for the first time in Russia used TIMES, a macroeconomic model developed under the aegis of IEA and based on ETSAP database of prices and technologies, which is broadly used worldwide (these analytical tools are combined in the TIAM complex), see Gordeev *et al*. (2011) and Kokorin *et al*. (2011). World Wildlife Fund (WWF Russia) was actively involved in the preparation of primary data for Russia and in the general task setting. The effort also sought to attain an important research goal: it was the first experience of running the TIMES model in Russia. This model always balances demand and supply by all types of products, including energy and financial resources. It does not let a country to "live on credit", so not all scenarios can be run.

From the modeling point of view, our calculations are in many respects similar to the research accomplished by IEA for Russia in IEA Outlook for Russian Energy (2011). However, an important dissimilarity was using GDP growth parameters equal to those used by the RF Ministry of Economy in the innovation scenario of the Projection (2013): 4% until 2030 (according to IEA, since 2010 average annual GDP growth equals 3%). Beyond 2030, GDP growth rates in our calculations are 3.5%, and beyond 2040 they are 3%. Like in the RF MED's innovative scenario, we assumed a higher, than IEA, energy efficiency improvement rate.

These calculations were made for the economically optimal development both with (second type scenarios) and without (first type scenarios above) a specific target, see Tables 1 and 2. This paper does not seek to provide a complete description of the modeling results, as there will be special publications on this topic. IEP is carrying on with the calculations, working with the TIMES model in cooperation with the Russian Presidential Academy of National Economy and Public Administration (ANE) and other research groups. Let us point out that in 2013 a review paper was published (Bashmakov & Myshak, 2013), which analyzes modeling efforts by all Russian research groups, including IEP and ANE. Therefore, here we shall only provide two of our results, which are most relevant to setting Russia's national GHG target for 2020–2030.

Firstly, our calculations confirm, that the innovation scenario, which includes active implementation of the energy efficiency and energy savings potential, indeed results in the GHG emission dynamics as shown in the RF MED projection for 2030, see Fig.4. The emission shows moderate growth at the beginning, then comes out on a plateau and finally goes down to 65–70% of the 1990 level. However, in the 2030-s emissions stabilize on this level, and special costly measures are required to further bring them down (for example, emission charges, which are yet to be justified by the estimates of damage caused by negative effects of climate change). Special measures might be taken earlier; for example, introduction of emission charges in 2015 would help to gradually reduce CO_2 emissions to 50–60% of the 1990 level, see Fig. 4.

Secondly, our calculations show that if our country's development is not accompanied by introduction of new technologies, which are already economically viable, we may have to face a substantial emission growth. Figure 4 shows the results of the BAU ("business-as-usual") scenario, which correlates with the innovation scenario by RF MED until 2030. The BAU scenario does not assume any special measures to reduce emissions, but the private sector shifts to new technologies as they become cost-effective. Along with BAU, a BASE scenario was calculated, in which GDP growth is the same as in BAU (4%), but no new technologies are introduced. Technology shift is prevented by other factors, not described in the model. These may include high business risks, too short business plan periods, outflow of capital, imperfect legislation or law enforcement practices, etc. Russia's energy-related GHG emission in 2010–2011 prompted us to calculate the BASE scenario (data for 2012 were not available at the moment of completing that work). In 2003–2008, it only grew up by 5%, in 2009 dropped by 5%, in 2010 recovered to reach the 2008 level, and in 2011 rose by another 5%, see Fig. 4. Therefore, in 2011 a substantial diversion from the BAU scenario was observed.

This might have been a result of environmental factors (a colder winter and/or smaller water run-off of rivers, which affects hydro power plants). However, in a large country like Russia, where a cold winter in one part of the territory is usually made up by a warm winter in the other part, etc., the role of environmental factors is relatively small, and so the reason is more likely the fact that cost-effective technologies are not being introduced. For a combination of reasons, the private sector chose a path, which is closer to the BASE scenario, than to the BAU. Obviously, this situation cannot last long, but at the moment we are facing a devastating emission growth.

The task for the near future is to direct the development along the economically optimal BAU scenario, i. e. remove barriers that are currently pushing the private sector to the BASE trajectory. If this is accomplished, the goal of keeping emissions at, or below, 75% from the 1990 level may be attained. Otherwise, if a shift from BASE to BAU takes place only around 2020, 80% of the 1990 level, or even a little more than that, should be expected. Of course, emission level is not the main problem; far more important is that this development trajectory has no positive perspective, bringing increasingly substantial loss of competitiveness and strong economic perturbations.

CONCLUSION

From the GHG emission dynamics point of view, global and Russian economic and energy sector development scenarios can be split into two groups. While in one group of scenarios the emissions grow, in the other they decline considerably. However, there is no inconsistency between them; the difference is determined by how climatic risks are accounted. In the first case they are viewed as negligible, while in the second they are dominating and requiring emission reduction regardless of costs. Directed by the precautionary principle, environmental organizations and the society insist on the implementation of the second type scenarios.

We will know which scenarios are more correct, i. e. find the truth in between, only when climatic losses and risks are correctly and in full detail calculated for all large countries of the world, including Russia. Damage and costs of adaptation to negative effects of anthropogenic climate change are to be compared with the costs of accelerated reduction of greenhouse gas emissions. Then it will be possible to develop models and scenarios of the third type, which would optimize ***overall costs*** over several decades or even a longer period.

TIMES, an internationally recognized model, was for the first ever time used in Russia for calculations. The results confirmed that the innovation scenario of Russia's development until 2030 prepared by RF MED leads to the stabilization of CO_2 emission level. Until 2020 the emission will be growing up to approximately 75% of the 1990 level, and by 2030 it will decline to 70%. These values can be taken as Russia's GHG targets until 2030. Further emission reduction will require taking special measures, for example, emission charges. Nevertheless, with coordinated emission reduction action by all largest countries, by 2050 Russia can reduce its emission to 50% or even less. This level can be taken as a global action target in the process of developing a new climate change agreement by the UN.

Attaining the above GHG goals requires economically optimal development of Russia's economy, with energy efficient technologies being introduced as soon as they become cost-effective. However, this has not been the case in the recent years. It is important to explore devastating GHG emission growth in Russia's energy sector and the entire economy in 2010–2011, and to minimize economic and legislative reasons behind this growth. This should be the core element of Russia's GHG emission reduction action in the near future.

REFERENCES

Agibalov S., Kokorin A. O., "Copenhagen agreement — a new paradigm of climate problem solving" [Kopengagenskoe soglashenie — novaya paradigma resheniya klimaticheskoy problemy]. *Voprosy Ekonomiki — Economic Issues*, 2010, no. 9, pp. 115–132 (In Russian).

Bashmakov I. A. (2009) *Low-Carbon Russia: The Year 2050* [Nizkouglerodnaya Rossiya: 2050 god]. Moscow, CENEf Publ. 197 p. (In Russian).

Bashmakov I. A., Myshak A. D. (2013) *Factors determining greenhouse gas emissions in Russian energy sector: 1990–2050. Part 2: Prognoses for 2010–2060* [Faktory opredelyayuschie vybrosy parnikovykh gazov v sektore ekonomiki Rossii: 1990–2050. Chast 2: prognozy na 2010–2060 gody]. CENEf Publ: Moscow, 107 p. (In Russian).

BP Energy Outlook 2030 (2012), London, BP, available online at: www.bp.com.

Deng Y. Y., Blok K., van der Leun K., "Transition to a fully sustainable global energy system", *Energy Strategies Review.* 2012, vol.1, issue 2, pp. 109–121, available at: http://dx.doi.org/10.1016/j.esr.2012.07.003.

ERIRAS-REA (2012) *Global and Russian Energy Outlook up to 2035* [Prognoz razvitiya energetiki mira i Rossii do 2035 goda]. Moscow, ERIRAS-REA, available at: http://www.eriras.ru/files/inei_rea_final1_0404dlja_sajta.pdf (In Russian).

ERIRAS-AC (2013) *Global and Russian Energy Outlook up to 2040*. ERIRAS-AC, Moscow, available at: http://www.eriras.ru/files/Global_and_Russian_energy_outlook_up_to_2040.pdf.

GEA (2012), *Global Energy Assessment — Toward a Sustainable Future*, Cambridge Univ. Press, Cambridge UK and NY, USA and the International Institute for Applied System Analysis, Laxenburg, Austria, available at: www.globalenergyassessment.org.

Gordeev D. S, Gritsevich I. G., Kokorin A. O. *Russian energy future 2050*. Regular ETSAP Workshop, Athens, 9 Nov. 2011, available at: http://www.iea-etsap.org/web/Workshop/Athens_Greece_Nov_2011/ETSAPGordeev.pdf.

GP & EREC (2009) *Energy revolution. Perspectives for establishment of a system of energy security of Russia. Russia energy [r] evolution*. Greenpeace International, EREC, available at: http://www.energyblueprint.info/822.0.html.

GP & EREC (2010) *Energy [r] Evolution a Sustainable World Energy Outlook*. Greenpeace International, EREC, available at: http://www.energyblueprint.info/1201.0.html.

G8 Declaration (2009) *Responsible leadership for a sustainable future*, Italy, available at: http://www.g8italia2009.it/static/G8_Allegato/G8_Declaration_08_07_09_final%2c0.pdf.

IEA WEO (2012) *World Energy Outlook 2012*, available at: http://www.worldenergyoutlook.org.

IEA (2012) *Energy Technology Perspectives 2012*, available at: www.iea.org.

IEA Special Report (2011) *Are we entering a golden age of gas? World Energy Outlook 2011*, available at: http://www.worldenergyoutlook.org/golden_age_gas.asp.

IEA Outlook for Russian Energy (2011) *World Energy Outlook 2011,* Part B, available at: http://www.worldenergyoutlook.org.

IPCC (2007), *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.). IPCC, Geneva, Switzerland, available at: www.ipcc.ch.

Kokorin A. O., Kuraev S. N., Yulkin M. A. (2009), *Review of the Nicolas Stern Report "Economic of Climate Change"* [Obzor doklada Nikolasa Sterna "Ekonomika Izmeneniya Klimata]. Second edition. WWF, SPF. Moscow, WWF Russia Publ., 60 p., available at: http://www.wwf.ru/resources/publ/book/329 (In Russian)

Kokorin A.O, Gritsevich I. G., Gordeev D. S. (2011) *Russian Energy Future 2050 and GHG Levels*. Yale Center for Environmental Law and Policy Webinar 17 November 2011, available at: https://yaleenvirocenter.webex.com/mw0307l/mywebex/default.do?siteurl=yaleenvirocenter.

Kokorin A. O., Smirnova E. V., Zamolodchikov D. G. (2013), *Climate Change. Book for Teachers of the Upper School.* [Izmenenie klimata. Kniga dlya uchiteley starshikh klassov obscheobrazovatelnykh uchrezhdeniy] Issue 1. Regions of the North of the European part and West Siberia of Russia. Moscow, WWF Russia, 220 p., available at: http://www.wwf.ru/resources/publ/book/807 Issue 2. Far East Regions. Moscow, WWF Russia, 234 p., available at: http://www.wwf.ru/resources/publ/book/809 (In Russian).

Macroeconomic Impacts of Climate Changes Assessment on the territory of Russia Federation for the Period up to 2030 and Further. [Otsenka makroekonomicheskikh posledstviy izmeneniya klimata na territorii Rossiyskoy Federatsii na period do 2030 goda i dalneyshuyu perspektivy] Kattsov V. M. and Porfirev B. N. (eds.). Moscow, Federal Service of Russia on Hydrometeorology and Monitoring of the Environment, 2011, 252 p., available at: http://www.voeikovmgo.ru/ru/otsenka-makroekonomicheskikh-posledstvij-izmeneniya-klimata (In Russian).

McKinsey & Company (2009) *Pathways to an Energy and Carbon Efficient Russia*. Moscow, available at: www.mckinsey.com.

NIR RF (2013). *National Inventory Report of the Russian Federation to the UNFCCC*, *Common Reporting Format,* available at: http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/rus-2013-crf-13apr.zip.

Prognosis of Social Economic Development of the Russian Federation by 2030 [Prognoz socialno ekonomicheskogo razvitiya Rossiyskoy Federatsii na period do 2030 goda] Russian Ministry of Economic Development. Moscow, 2013, 337 p., available at: www.economy.gov.ru (In Russian).

Roshydromet (2008), *Assessment Report on Climate Change and Its Consequences in Russian Federation* Meleshko V. P. & Semenov S. M. Roshydromet: Moscow, available at: http://climate2008.igce.ru/v2008/pdf/resume_ob_eng.pdf.

Schellnhuber, H., Hare, B. *et al.* (2013), *Turn down the heat: climate extremes, regional impacts, and the case for resilience — full report*. Washington DC: World Bank, available at: http://documents.worldbank.org/curated/en/2013/06/17862361/turn-down-heat-climate-extremes-regional-impacts-case-resilience-full-report.

Special Report of the Intergovernmental Panel on Climate Change (2012) *Managing the risks of extreme events and disasters to advance climate change adaptation*. IPCC, available at: www.ipcc.ch

The Economics of Climate Change (2006) The Stern Review, HM Treasury, UK.

Trends in Global CO_2 Emissions, 2012 Report (2012). EC Joint Research Center, PBL Netherlands. 40 p., available at: http://edgar.jrc.ec.europa.eu/CO2REPORT2012.pdf.

Veselov F. V. Makarov A. A., Malakhov V. A. (2012) *Scenarios of CO_2 emissions in Russia by 2050 — Energy and Economics Dimension*. [Stsenarii emissii CO_2 v Rossii do 2050 goda — energeticheskoe i ekonomicheskoe izmerenie]. ERIRAS. Presentation in Carnegie Centre. Moscow, 26 January 2012 (In Russian).

WWF International & Ecofys (2011) *The Energy Report. 100% Renewable Energy by 2050*. WWF, Ecofys, OMA. 2011, 253 p., available at: http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/energy_solutions/renewable_energy/sustainable_energy_report/.

Ways to Maintain Sustainable System of Managing Reputational Risks Within Suppliers Relations*

Taisiya IZNOVA
Economic Analysis Department, Financial University, Moscow
i_taisia@mail.ru

Olga EFIMOVA, Ph. D., Professor
Economic Analysis Department, Financial University, Moscow
oefimova2002@mail.ru

Abstract. Reputational risk is the main threat to one's ability to maintain sustainable development because it influences company's long-standing position. However, very little empirical research has been carried out to determine how to manage reputational risk using sustainability reporting. This paper addresses the problem of reputational risk within supplier relations system. The paper proposes an approach based on identification of key suppliers to understand their needs and expectations and development of specific recommendations on disclosure. In the paper we propose a methodology of assessing reputational risk in supplier relations system. For this purpose it was proposed to divide suppliers depending on geographical criteria and duration of cooperation with the client company. Also an approach was proposed to select expectation criteria and indicators. It must be underlined that by reputational risk we understand the probability that reputation will suffer, and direct economic loss will follow. That loss can be regarded as reputational loss. Having assessed probable reputational loss it seems reasonable to propose indicators to disclose. Such indicators are proposed for both the internal accounting system (to manage reputational risk) and for disclosure to third parties. Results of the assessment showed significance of suppliers relationship system control and represented indicators to disclose.

Аннотация. Репутационный риск представляет собой главную угрозу для способности компании к поддержанию устойчивого развития, поскольку данный риск оказывает влияние на долгосрочное положение компании. Однако проведено крайне мало эмпирических исследований с целью определить, как управлять репутационными рисками с помощью отчетности по устойчивому развитию. В настоящей статье рассматривается проблема репутационных рисков в системе отношений с поставщиками. В работе предлагаются подход, основанный на определении ключевых поставщиков с целью идентификации их потребностей и ожиданий, и разработка конкретных рекомендаций по раскрытию информации. В исследовании предложена методология оценки репутационных рисков в системе отношений с поставщиками. Для реализации данной цели было предложено разделить поставщиков в зависимости от географического критерия и длительности сотрудничества с компанией клиента. Также было предложено установить критерии ожиданий и их показатели. Следует подчеркнуть, что под репутационным риском мы понимаем вероятность ухудшения деловой репутации и последующие прямые экономические потери, которые можно отнести к репутационным потерям. Оценив вероятные репутационные потери, представляется разумным предложить показатели к раскрытию. Такие показатели предложены для обеих систем — внутреннего учета (в целях управления репутационными рисками) и раскрытия информации для заинтересованных лиц. В результате проведенной оценки показана значимость контроля за системой отношений с поставщиками и предложены показатели к раскрытию.

Key words: Assessing reputational risks, suppliers relationship system, stakeholder expectations.

* Разработка устойчивой системы оценки репутационных рисков компании в отношениях с поставщиками

INTRODUCTION

Sustainable development has been defined in many ways, but the most frequently quoted definition, which has been proposed by World Commission on Environment and Development (1987), is that sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. As it was marked by Steurer (2002) Brundtland Report outlined sustainable development as an environmental concept for the macroeconomic level.

Applying this definition regarding corporation limits we realize that on one hand corporations are definite parts of the world economy's sustainable development process, on the other — they are economic units which face the necessity to maintain their own sustainable development.

As R. Steurer and M. E. Langer (2005) underline in their research from a historical point of view, shareholders relations management (SRM) emerges as the latest stage of an old research tradition which addresses various forms of business–society relations. Numerous works in this tradition can be found throughout the 20th century (Clark, 1939; Bowen, 1953; Heald, 1957; Walton, 1967). However, while neoclassical economists saw firms as closed systems only concerned about their shareholders, those focusing on business–society relations opened the firm up to its societal context and, thus, positioned themselves beyond the neoclassical mainstream (Dill, 1958; Andriof *et al.,* 2002) — at least until the mid 1980s. In 1984, Freeman's (1984) book *Strategic Management: A Stakeholder Approach* established SRM as a popular research field.

Based on Adam Smith, the neo-classical economic paradigm perceives firms as more or less closed systems with their only concern being the satisfaction of their shareholders. However, from the early 1980s onward, a new business–society paradigm unfolded, "articulating the need for business to be, in some respect, responsible to society" (Andriof *et al.,* 2002). As it has been argued by Cragg and Greenbaum (2002), a critical point of this new paradigm is that "corporate officials confront the world as an arena of opportunities and constraints in relation to organizational goals", whereby the definition of this arena strongly depends on stakeholder interests.

Edgley (2010) underlines that firms seem to have a pressing need to understand and meet stakeholder information needs, perhaps because firms need to better report information with a view to "inform or influence its target audience".

As it has been demonstrated through numerous researches, the possibility of company to develop sustainably is determined by its ability to satisfy all the stakeholders groups and to keep the balance of their interests.

Suppliers relationship system and its reputational risk dramatically influence client company opportunities to maintain sustainable development for following reasons:

- Reputational risk is the main threat to sustainable development ability because the considered risk influences company's long-standing position;
- Effective suppliers relationship system can minimize informational influence and manage expectations;
- Only by applying deep consideration system of suppliers perception client company is able to maintain long-lasting relationship, when all of the parties get their benefits.

1.1 CONTEXT

The system of corporate reporting is a subject to constant development, caused by ever-changing expectations and demands on the part of stakeholders, particularly shareholders and investors. At the same time, the demands of this group are ultimately aimed at building the effective relationship system with a diverse group of stakeholders — employees, customers, suppliers, local communities and the media. By effective relationship we mean a system of relations where the costs are predictable and controllable, and cooperation leads to the increment of company's value and contributes to the sustainable development of the company.

Reputational risk is the main risk, a threat to a system of effective relationships with stakeholders, and corporate reporting in its turn is the main tool for controlling this risk. At present, more and more companies realize that their corporate reporting can be a powerful tool that allows maintaining a dialogue with stakeholders, thus solving a critical problem of managing reputational risk.

Economist Intelligence Unit's research (2005) demonstrated that reputational risk is at the top of risk managers' list of priorities; it is perceived as substantially more significant factor than regulatory risk and human capital risk. Though the reputational risk has been ranked that high, the topic still remains uncovered. Regulators, industry groups, consultants, and individual companies have developed elaborate guidelines over the years for assessing and managing risks in a wide range of areas, from commodity prices to control systems to supply chains to political instability to natural disasters. Eccles (2007) underlines that, in the absence of agreement on how to define and measure reputational risk, it has been ignored.

The problem of reputational risk as category is widely covered by many authors (Arif Zaman, Jenny Rayner, Alex Harris). This paper addresses the problem of reputational risk within supplier relations system. The paper proposes an approach based on identification of key suppliers to understand their needs and expectations and development of specific recommendations on disclosure.

1.2. RESEARCH DATA

In the paper we propose a methodology of assessing reputational risk in supplier relations system. To develop this methodology we have analyzed the sensitivity of 9 groups of suppliers. To provide the analysis we have reviewed 15 suppliers: 30% of them were local; 13% were global overseas and 57% were overseas local suppliers. 13% of suppliers structure were agents, 87% were direct suppliers. Constant suppliers occupy 30%, new suppliers — 13%, existing — 57%. Suppliers provide the company with chemical raw materials and equipment.

1.3. HYPOTHESIS DEVELOPMENT

The above discussion on the value of information for managing reputational risks helps in formulation of the following hypotheses:

Hypothesis 1: Status of supplier company and duration of cooperation with the client company influence the sensitivity of information perception.

On the first stage we propose to analyze company suppliers' structure depending on their geographical position and duration of cooperation with the company. Expectations from global suppliers are always higher than those from local partners. Yet making relationship with global suppliers lays risk-free basis for client company supply chain, while selecting international local suppliers provides added value.

Hypothesis 2: Status of the supplier company and duration of cooperation with the client company define threshold of sensitivity.

On the second stage we propose to use estimation of risk probability. Since reputational risk constantly influences the business, its minimal value is proposed to be (0, 1). Analyzing informational criteria we basically use interval (0, 1) for different suppliers groups. If compliance with proposed criteria has critical importance for new or constant supplier, than probability of reputational risk occurrence can stay constant for local and overseas suppliers. If geographical characteristic of supplier has critical influence, than probability of reputational risk occurrence can stay constant for new and constant partners for example.

Hypothesis 3: Suppliers sensitivity to client involvement into cases where other stakeholders' rights are infringed, prospects of cooperation are not clear and can only be assessed with interval value.

Hypothesis 4: Reputational losses differ from reputational risk, loss significance can be assessed.

Among most common reputational losses we define the situation when quality performance will be insufficient; probability of price increase; refusal to cooperate; failure to meet contract obligations on delivery.

Hypothesis 5: Internal accounting indicators can make significant contribution to identifying reputational risk.

A company willing to decrease reputational risk has to provide internal analysis of supplier relations practice to assess whether an inappropriate response is taking place.

Hypothesis 6: External disclosed indicators can make significant contribution to managing expectations which form reputational risk.

2. METHODOLOGY

2.1. FIRST STEP: ANALYZING SUPPLIERS STRUCTURE CONDITIONALLY ON CERTAIN CRITERIA

For the purpose of identifying the expectations of suppliers, which bring to reputational risk occurrence, we propose the following classification of suppliers — we distinguish three main groups depending on duration of cooperation with the company:

- New suppliers;
- Existing suppliers;
- Constant suppliers.

The expectations of suppliers also must be adjusted depending on the geographical characteristics:

- Local suppliers;
- Global overseas suppliers;
- Local overseas suppliers.

Local suppliers are those, whose country of origin matches with client company country; global overseas suppliers are widely admitted as "global suppliers", have widely diversified branches and provide supplies all over the world. Local overseas suppliers are those, whose country of origin differ from client company country and who do not have that much experience in export activity.

The main feature of the new suppliers is the lack of experience of working with the client, hence the expectation is automatically distorted in the direction of overstating or understating.

Usually in the relations with new suppliers concerning main points (project price, client qualification, transparency, etc) reputational risk level is on its maximal value, as this group is not aware of customer routine procedures in relationship with suppliers. When it comes to contract signing procedures or additional requirements from client, the risk level is a bit lower than for existing and constant suppliers.

Existing suppliers already have experience of working with the client, their expectations are generally already adjusted, but they have not yet moved into the category of constant, hence they have high expectations about the prospects of cooperation.

Constant suppliers are aware of all the features of cooperation with the client, and because of the relationship degree, customer reputation affects them deeply, so this group is most sensitive to changes associated with the reputation of the client, as well as to the prospects of cooperation, as they expect to be the first partners to receive information about upcoming structural, industrial changes of the client, new business directions, new contract possibilities.

If the customer company is a global client, who provides IFRS/GAAP reporting statement and leads finance activity in Europe or the U.S., then the requirements are becoming stricter. In this case it is really complicated for local suppliers to follow international standards and to meet the needs of global clients. Local suppliers' prices are usually lower and the products are less competitive, while their expectations are minimal. Local suppliers are less susceptible to the news about the client company, as their own reputation is not that significant.

Local suppliers are able to respond more flexibly to the new order inquiry, if necessary, to make changes to an existing one, due to shorter period of transportation. The quality system is also easier evaluated in relations with local suppliers, as both parties lead their activity within one system of standards.

Global overseas suppliers have high expectations in every aspect — from selecting the right supplier to the allegations of the complaint. Also, these providers do not tend to individualize products that provide related services which are not regulated under the contract.

Contracts with overseas local suppliers bring the highest level of risk, so the services of agents can be used to mitigate the customers' risks. It is reasonable to set the amount of costs of work with overseas local suppliers, highlighting the amount of agency contracts. The peculiarity of the relationship with the agents is that, usually the agents supply more than one type of products or services, and they are also interested in signing and bringing to the end of the transaction under any circumstances. Carrying collaboration with overseas local suppliers agents eliminate the risks, as the resolution of conflicts due to different technical and safety standards is the task of the agent.

2.2. SECOND STEP: IDENTIFYING SUPPLIERS EXPECTATIONS AND ASSESSING RISK SIGNIFICANCE

In order to provide suppliers relationship analysis it seems reasonable to identify the following 8 factors. Failure to meet expectations on proposed factors can probably bring to reputational risks occurrence (Appendix 1).

1. Placing order procedures is considered to be the first stage in negotiation process which proves seriousness of client's intentions. Setting unfeasible deadlines to provide proposals, inexact order and timing of order requirements demonstrate client's reluctance to select the most appropriate supplier.

Suppliers in their turn set their expectations while carrying preliminary contract discussions. The high value has been placed on such factors as: quantity of client inquiries which have been made before accepting supplier offer; sufficiency of client projected budget relative to market price of work required; client qualification as a customer.

Evidently that having received price inquiry without further contract conclusion is interpreted by supplier as market research carried by the client. At the time of next inquiry the price will probably increase, so it seems necessary to keep the statistics of price inquiries which have not lead to contract conclusion. Reasonable assumption is that when inquiry appeals once the probability of reputational risk occurrence has its minimal value which is 0,1%, the probability increases simultaneously with further appeals, reaching its maximum value (100%) after the third client inquiry.

Assessing project benefits the supplier analyses adequacy of client projected budget relative to costs required; when the current/market price ratio is on low level it implies higher expectations on further collaboration or probability that product/service quality will be not sufficient in order to provide supplier margin. If the projected budget/current market price ratio exceeds or equals 1, client is free to choose the best supplier, reputational risks are at minimal value 0,1. 0,70–0,65 gap is valid when supplier has intention to sell the product at its cost value, which can be explained by one of following reasons — higher expectations concerning new projects, supplier cash flow gap or product illiquidity. When the current/market price ratio is lower than 0,65, probability of reputational risk increases up to maximum 1, because such ratio indicates that product quality is not sufficient.

Analyzing "client qualification as a customer" criteria we assess sufficiency of resources required to carry purchasing procedures. The list of required resources is defined by industry but includes existence of qualified employers, capable of making clear product technical requirements, carrying the delivery process, obtaining all the license, patents, carrying similar purchase experience. All the above factors presence reflects in documentation package; this package sufficiency can be limited to minimal, enhanced or provide additional data on client business.

2. The second proposed factor is transparency of supplier selection and approval policy. The factor is valuable as supplier has to have clear vision of criteria required to collaborate with client. If company is looking to provide additional value and selects the supplier whose activity does not respond to client supplier selection policy, following risks must be recognized.

To provide order details transparency, the data on suppliers' requirements, consideration of submitted applications and sizing up deadlines are to be publicly available.

So that if required data is available, the probability of reputational risk occurrence is at its minimal value, if transparency is incomplete the risk probability is 0,3–0,5. If the price is inquired in low-transparent way, risk probability achieves 0,8 level.

3. Supplier approving and contract signing procedures duration. Long approving, control and contract signing procedures are peculiar to large corporations. If waiting period makes the contract performance impossible, disrupts production plan or brings to supplier significant losses, reputational risks increase. When assessing possible reputational losses one should realize that supplier can fail to perform the contract.

In every sphere there are routine supplier approval and contract signing procedures. The closer duration to its extreme value, the higher reputational risks are. To manage such expectations the company management can publish required information on how long it takes to approve the contract through internal control system, underlining time required for new suppliers.

4. Quality of contract obligations fulfillment. If main contract obligations (first of all payment terms) are not fulfilled properly, this brings to reputational risks occurrence. When a client makes payment before the agreed period it leads to increase of supplier's trust, but at the same time it raises suppliers expectations about payment terms practice. Still if the client violates payment term having tentative agreement it inevitably increases reputational risks. Reputational losses depend on payment terms.

5. Additional requirements, which are not regulated by contract. As the contract is being performed client can make demands concerning transportation conditions, time of delivery, payment terms, and documentation process. One should realize that if supplier's expenditure required to satisfy these demands is higher than expected, supplier will reimburse it subsequently.

If the client doesn't make such kind of demands, reputational risk is on its minimal value, but in practice it is very rare. When such demands do not damage the interests of the parties, reputational risks will mainly influence the relationship with constant suppliers, where agreed routine procedures exist.

When additional demands do violate the interests of the parties, reputational risks most insignificantly appear in international local suppliers relationship, as for such suppliers it is also routine when international client makes lots of additional demands, which are regulated by the law of client's country.

6. Issues of relationships with other suppliers (litigation, payment defaults, etc.). The practice of relationships with other suppliers demonstrates the dangers that threaten the supplier. Mainly this contributes to high-profile events such as termination of contracts, defaults and subsequent legal proceedings.

7. Relationships with other groups of stakeholders, which may affect the supplier directly. Layoffs, termination of individual contracts with clients, failure to comply, environmental and social security, unreasonable credit policy, differences among the major shareholders and investors, facts of fraud connected with the client company's activity — all this could have an impact on the customer's ability to meet its obligations as the seller.

8. Prospects of cooperation: Suppliers who made a single-time delivery may have high expectations only about upcoming contracts. It is important that the supplier is informed of the results of the first delivery, aware of the reasons for refusal if another order is not planned. If prospects of cooperation are not quite clear, suppliers expectations are not satisfied, customer company can face future loss, if faces with the need to carry out an order from the supplier. To avoid such a situation, it is important to inform the provider about the prospects of the order, and the reasons of refusal.

2.3. THE THIRD STEP: ELIMINATING POTENTIAL REPUTATIONAL LOSSES AND INDICATORS TO DISCLOSE

We need to single out the main areas of reputational risk in relations with suppliers. The main method of minimizing is the constant monitoring of problematic issues and disclosure of information in case of need. By disclosing we mean creating analytical forms for internal analysis to manage the threats as well as providing information for external users to manage expectations.

After analyzing the stages of negotiations with suppliers criteria were identified to determine their expectations and possible future losses defining reputational risk. In order to minimize the risks key performance indicators that allow the client company to control the reputational risks were proposed. Internal accounting indicators are intended to provide the company management with self-assessment system, which is the way to manage reputational risk on the stage when the risk is still manageable. For example, by assessing its own staff qualification, adequacy of budget/market ratio etc., the company's management gets an opportunity to understand possible reputational risks.

Indicators to disclose are necessary to manage stakeholders' expectations. By revealing costs on long-terms contracts and routine admissions company can influence expectations hereby taking control of reputational risks.

Proposed data is shown in Appendix 2. Assessing supplier relationship system, following losses seem most common in practice: failure to meet contract obligations on delivery time; probability that quality performance will be insufficient; probability of price increase; refusal to cooperate. To avoid these losses, the suppliers expectations must be adjusted through the disclosure system, at the same time internal indicators must be analyzed to change relationship style where it is critical.

The proposed methodology can be applied to most significant suppliers, which are important to the client company because of high quality or internal value added, where it is critical to safe long-lasting relationships.

3. DISCUSSION, CONCLUDING COMMENTS AND LIMITATIONS

The paper explores suppliers' informational expectations and perceptions of customer behavior. Findings suggest probability of reputational risk occurrence and possible reputational losses.

Managing reputational risk is a complex challenge for every company. In the paper we propose part of supplier relationship analysis methodology. Final purpose of such analysis is to make a contribution to minimizing the risk.

On one side suppliers themselves bring the risk into company's supply chain, on the other the system of supplier relations is subject to reputational risk. If risk level is not an object of proper control, losses can be enormous.

In the article we have examined suppliers. The problem is that many client companies underestimate the importance of relationship with suppliers, but this relationship dramatically influences client company's own clients and whole business.

Reputational risk increases when stakeholders' expectations are higher than reality, so the best way to manage the risk is to manage expectations. By improving disclosure policy the company can manage expectations.

The best way to manage expectations about standards and procedures is to disclose time usually required; about budget sufficiency — price justification; about conflicts of interests — reasons and following policy details.

Limitation 1: For sure every company has its own limitations of sensitivity to business events. Proposed expectation criteria can be changed as well. To carry this research we highlighted general positions. Every expectation area can be assigned with its share (specific weight) to assess aggregated reputational risk indicator.

Limitation 2: List of reputational losses can be specified. In practice a deep analysis cannot be applied to all suppliers, but to those whose contribution to value creating process is the most substantial.

The purpose of the research is to realize reputational risks in connection with client company behavior. Reputational risk is on its maximum in cases when:

- Quantity of client inquiries exceeds 3 times for all suppliers groups;

• Sufficiency of client projected budget relative to market price of work required is less then 0,65;

• Minimal data on client company profile is available (constant suppliers is the only exception);

• Order details transparency is not sufficient. In constant suppliers relationship risk occurrence probability is indicated as 0,75;

• Duration of supplier and contract approving procedures exceeds routine admissions (for all suppliers groups) and is less than admissions for new suppliers;

• Failure of contract obligations takes place (concerning payment terms; acceptance procedures of product/services; making claims);

• Client company makes requirements that infringe interests of the parties (new suppliers is only exception);

• There are no visible prospects of cooperation.

To propose reputational risk analysis system we can define several expectations areas, where reputational risk level can be assessed only as an interval:

• Analyzing influence of conflicts in relationships with other suppliers on concerned supplier relationship system, we can say that interval value will start with 0,3–0,6 (depending on supplier group) and complete with maximum 1 value;

• Assessing influence of conflicts in relationships with other groups of stakeholders interval value will start with 0,2–0,6 (depending on supplier group) and complete with maximum 1 value;

• When prospects of cooperation are not critical the interval value will also depend.

To manage reputational risks company should provide independent self-assessment procedures. That is why we propose to define internal accounting indicators, to be implemented to assess how company fulfills its own obligations and how conflicts within other stakeholders relationship can influence the suppliers business from supplier's point of view.

We also propose informational indicators to disclose, which are to explain improper actions of client company and to minimize stakeholders' reaction.

By developing the system of reputational risk controlling means and developing an independent self-assessment system, company is to answer the question "What do stakeholders really think?" To implement this purpose company has to assess step by step how its business attitude is being perceived by stakeholders. Approach which makes its contribution to realization of company's influence on other stakeholders groups is the only proper approach to maintain sustainable development.

REFERENCES

Zaman A. (2004), *Reputational Risk: How to Manage for Value Creation*, Financial Times Pearson Education.

Rayner, J. (2004), *Managing reputational risk: Curbing threats, leveraging opportunities*, Vol. 6, Wiley.

Eccles R. G., Newquist S. C. and Schatz R. (2007), "Reputation and Its Risks", *Harvard Business Review*, February 2007.

Economist Intelligence Unit (2005), "Reputation: Risk of risks' [online at: http://www.eiu.com/report_dl.asp?mode=fi&fi=1552294140.PDF&rf=0].

"GRI Guideline G4 (developing version) " (2012) [online at: www.globalreporting.org].

"Report of the World Commission on Environment and Development" (1987) [online at http://www.un.org/documents/ga/res/42/ares42–187.htm].

Steurer R., M. E. Langer, Astrid Konrad, Andre´ Martinuzzi (2005) "Corporations, Stakeholders and Sustainable Development I: A Theoretical Exploration of Business–Society Relations", [online at http://www.environmentalmanager.org/wp-content/uploads/2008/01/corporations-stakeholders-and-sustainable-development.pdf].

Appendix 1.

Suppliers expectations			Probability of reputational risks occurrence for different groups of suppliers								
			New			Existing			Constant		
Expectations area	Expectation criteria	Indicators	Local	Overseas global	Overseas local	Local	Overseas global	Overseas local	Local	Overseas global	Overseas local
Placing an order procedures	Quantity of client inquiries	1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
		2–3	0,5	0,5	0,4	0,6	0,6	0,5	0,8	0,8	0,8
		>3	1	1	1	1	1	1	1	1	1
	Sufficiency of client projected budget relative to market price of work required	⩾1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
		0,85–1	0,3	0,3	0,3	0,25	0,25	0,25	0,2	0,2	0,2
		0,65–0,85	0,5	0,65	0,7	0,45	0,45	0,45	0,45	0,45	0,45
		<0,65	1	1	1	1	1	1	0,9	1	1
	Client qualification as a customer	Min. data on company profile	0,75	0,95	0,85	0,45	0,65	0,55	0,15	0,15	0,15
		Extended data	0,3	0,3	0,1	0,2	0,2	0,1	0,1	0,1	0,1
		Additional data	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Transparency of supplier selection and approval policy	Order details transparency	Complete	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
		Incomplete	0,4	0,5	0,3	0,4	0,5	0,3	0,3	0,4	0,2
		Unicast	0,9	0,9	0,9	0,9	0,9	0,9	0,75	0,75	0,75
Supplier approving and contract signing procedures duration	Compliance of approving duration with routine admissions existing in the sphere	Less than minimal required	1	1	1	0,3	0,3	0,3	0,2	0,2	0,2
		Minimal required	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
		Maximum required	0,3	0,3	0,3	0,4	0,3	0,3	0,5	0,3	0,4
		Failure to meet deadlines	1	1	1	1	1	1	1	1	1
Quality of contract obligations fulfillment	Payment terms; Acceptance procedures of product/services; Making claims system;	Fulfillment	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
		Fulfillment within max agreed period of time	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25
		Non-fulfillment	0,9	0,9	0,9	0,9	0,9	0,9	1	1	1

Suppliers expectations			Probability of reputational risks occurrence for different groups of suppliers								
			New			Existing			Constant		
Expectations area	**Expectation criteria**	**Indicators**	**Local**	**Overseas global**	**Overseas local**	**Local**	**Overseas global**	**Overseas local**	**Local**	**Overseas global**	**Overseas local**
Additional requirements, which are not regulated by contract	Timely informing on changing circumstances; Timely inquires on additional demands;	Absence	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
		Requirements that do not infringe interests of the parties	0,3	0,3	0,3	0,35	0,35	0,35	0,40	0,40	0,40
		Requirements that infringe interests of the parties	0,5	0,6	0,4	0,9	1	0,9	1	1	1
Conflicts of interest in relationship with other suppliers	Withdrawal of significant batch from the market; Repudiation of significant contracts; Payment defaults; Litigations		0,4–1	0,6–1	0,4–1	0,4–1	0,4–1	0,4–1	0,3–1	0,4–1	0,3–1
Conflicts of interest in relationship with other groups of stakeholders	Significant layoffs; Termination of significant contracts with clients; Failure to comply, environmental and social security; Unreasonable credit policy; High scale investment projects; Conflict of interest among the major shareholders and investors; Internal level of fraud within the client company		0,2–0,3	0,3–0,4	0,2–0,3	0,2–0,3	0,3–0,4	0,2–0,3	0,5–1	0,6–1	0,5–1
Prospects of Cooperation	Prospects of orders Joint projects Commercial terms of delivery	Attractive	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
		Not principal	0,2–0,4	0,2–0,4	0,2–0,4	0,3–0,5	0,3–0,5	0,3–0,5	0,8–0,9	0,8–0,9	0,8–0,9
		No visible prospects	1	1	1	1	1	1	1	1	1

Appendix 2.

Stage of negotiation process	Expectations Criteria	Potential Losses	Internal accounting informational indicators	Informational indicators to disclose
Placing an order procedures	Quantity of client inquiries	In case of placing an order, the price increases; Supplier can refuse to make business with the company	The number of price requests, which did not lead to signing of contract	Ordered product requirements
	Sufficiency of client projected budget relative to market price of work required	Probability that quality performance will be insufficient;	Analytical comparative figures;	Justification of price; Projected orders in this area;
	Client qualification as a customer	Improper performance of obligations; Litigation;	Staff experience in procurement activity;	Extended information company profile and the state of the resources;
Transparency of supplier selection and approval policy	Order details transparency	Supplier can refuse to make business with the company	Deep analysis of supplier approval policy	Percent of costs on suppliers, which have signed long-term contracts; Percentage of costs on new suppliers, which perform the order for the first time; The number of refusals on the stage of supplier proposal; The number of refusals according to results of full-scale testing;
Supplier approving and contract signing procedures duration	Compliance of approving duration with routine admissions existing in the sphere	Failure to meet contract obligations on delivery time; Probability that quality performance will be insufficient Probability of price increasing	Comparative data on time required to approve the supplier concerning routine admissions existing in the sphere	Average period of time required to approve the supplier/sign the contract; Percentage of contracts, approving time for which exceeds agreed duration
Quality of contract obligations fulfillment	Payment terms; Acceptance procedures of product/services; Making claims system;	Failure to meet contract obligations on delivery time; Probability that quality performance will be insufficient Probability of price increasing;	Compliance of performance with contract obligations	Payables by age; Number of claims;

Stage of negotiation process	Expectations Criteria	Potential Losses	Internal accounting informational indicators	Informational indicators to disclose
Additional requirements, which are not regulated by contract	Timely informing on changing circumstances; Timely inquires on additional demands;	Failure to meet contract obligations on delivery time; Probability that quality performance will be insufficient	Changes associated with the customer, which the supplier may not be aware, and which may affect the performance of the contract;	Reservations about the possibilities of the client to put forward additional requirements;
Relationships with other suppliers	Withdrawal of significant batch from the market	Probability of price increase; Refusal to cooperate;	Statistics of such cases, indicating the level of importance;	Disclosure of information on the causes of conflict and internal control measures taken
	Repudiation of significant contracts			
	Payment defaults			
	Litigations			
Relationships with other groups of stakeholders	Significant layoffs; Termination of significant contracts with clients; Failure to comply, environmental and social security; Unreasonable credit policy; High scale investment projects; Conflict of interest among the major shareholders and investors; Internal level of fraud within the client company.	Probability of price increase; Refusal to cooperate;	Statistics of such cases, indicating the level of importance;	Disclosure of information about the causes of conflicts and the possible impact on other stakeholders and the internal control measures taken
Prospects of Cooperation	Prospects of orders, joint projects, commercial terms of delivery.	Probability of price increase; Refusal to cooperate.	The practice of co-operation; The projected procurement plan.	Prospects of orders; Number of terminated contracts.

Impact Investment as a New Investment Class*

Michał FALKOWSKI, Ph.D. Candidate
University of Management & Finance in Warsaw, Business Analyst, Excelian Limited
mfalkowski@poczta.onet.pl

Piotr Wiśniewski, Ph.D.
Associate Professor, Department of Corporate Finance, Warsaw School of Economics
piotr.wisniewski@sgh.waw.pl

Abstract. Impact investment has emerged as a socially aware response to contemporary socioeconomic challenges. The combined pursuit of investment efficiency with proactive furtherance of socially beneficial goals appears particularly relevant in an era of recurring risk aversion, capital volatility and stringency in public funding. This study sums up the early evidence of impact investment: its origins, philosophy, taxonomy and evolution. The key research dilemma addressed herein boils down to whether impact investment will transpire as a distinctive class of institutional financial management. The social arguments for its expansion are undisputable, however, to succeed in the long term impact investment will have to enhance its internal organisation and classification, improve reporting transparency and ensure lasting commitments from governments, international organisations and private contributors.

Аннотация. "Инвестиции влияния" (impact investments) возникли как ответ на социально-экономические вызовы нашего времени, для которого характерно стремление одновременно к росту эффективности инвестиций и к реализации общественно полезных целей. Данное исследование суммирует характеристики "инвестиций влияния", включая их предысторию, философию, систематизацию и эволюцию. Главная дилемма исследования сводится к вопросу о том, смогут ли "инвестиции влияния" стать самостоятельным классом институционального финансового менеджмента.

Key words: institutional-, socially responsible-, alternative investment; social impact.

DEFINITION AND SIGNIFICANCE OF IMPACT INVESTMENTS

The investment process has varying associations in economics and finance. An investment can be defined as an asset or an item purchased in the hope of generating **future returns** or appreciating in **value** (Myles, 2003). In the economic sense, an investment is the purchase of goods not consumed today but rather used in the future to create wealth (TD Direct Investing, 2010). In finance, an investment represents a monetary asset purchased with a view of providing a future income or a capital gain (cf. Power Management Institute, 2011). Clearly, all the aforementioned approaches underscore potential future gains and highlight the financial aspects of investment commitments.

Evidently, the recent financial crises (e. g. the global economic contraction of 2007–2009 and the European sovereign debt woes) have shaken firmly established beliefs regarding the risk and return profiles of traditional investments. In the course of that period investors had to very often reanalyse their portfolios as the firmly established risk-return spectrum (low risk — low return; high risk — higher return) turned out to be irrelevant to the market events of that time. During those recent economic depressions, global stock markets have contracted dramatically, large financial institutions have collapsed or have had to be salvaged, and governments (even those of the wealthiest nations) have had to concoct rescue packages to bail out their decrepit financial systems. However, despite cross border rescue actions financial markets still remain quite volatile mainly due to uncertainty regarding the stability of the world economy which has its impact in the overall risk aversion of institutional and individual investors. In such challenging circumstances, both institutional and individual investors tend to seek alternatives in their traditional portfolios. One of the novel (but still marginal in magnitude) investment styles is the so-called "**impact investment**".

According to different sources impact investment, often referred to as "social investment" or "sustainable

* «Инвестиции влияния» как новый инвестиционный класс

investment", is defined as actively placing capital in businesses that generate social and/or environmental good and at the same time provide a range of returns, from principal to above market performance (cf. Monitor Institute, 2009). Another definition labels impact investments as capital deployed to seek both positive social outcomes and financial returns (Evenett, Richter, 2011). According to a 2010 J. P. Morgan report, impact investments are investments "intended to create positive impact beyond financial return" (O'Donohoe *et al.* 2010). As such, they require the balancing of social and environmental goals in addition to financial risk and return. As per the Global Impact Investing Network (GIIN), impact investment strategies range from the simple return of principal capital to offering market rate or even competitive market financial returns to investors (Global Impact Investment Network, 2009). The Centre of Global Development (Simon and Barmeier, 2010) mentions another feature of impact investing. They claim that impact investment provides capital to businesses that target environmental and social issues that are not targeted by current official development efforts or traditional private investors. Hence they state that impact investing should be additional to commercial funding. Otherwise there would be no need for the impact investors that target the spectrum of capital between philanthropy and traditional commercial investing. However the feature of additionally seems to be less often referred to by other reports on impact investing.

Despite various attempts at defining **impact investment** as an emerging asset class, it is important to distinguish it from the (by far more established) notion of **Socially Responsible Investment** (SRI), which generally seeks to minimise negative impacts rather than proactively effect positive social or environmental changes (cf. Viviers *et al.*, 2009). SRI has historically been described as financing companies that favour strong environmentally and socially aware policies and that abstain from socially costly industries, such as alcohol, tobacco, gambling or weaponry (Pan, Mardfin, 2001). As SRI are identified by screening out ("negative screening") companies or industries with bad environmental protection histories they do not seek to promote business models that by their nature deliver positive social benefits. Social entrepreneurship refers to the creation of new approaches to attack social problems. Such models are often not-for-profit and seek grant capital instead of investment.

Since impact investment has often been erroneously labelled merely as a subclass of SRI, it is worth reiterating that impact investing contrasts with SRI by virtue of the **intent** and **primary purpose** of investment allocation. In implementing a passive strategy that excludes certain portfolio elements basing on a predefined set of criteria, SRI mainly aims for financial returns while endeavouring to accomplish some other (but not necessarily social and/or environmental) objectives.

To highlight the above-mentioned difference between SRI and impact investments we can emphasize some of the main goals of JP Morgan Urban Renaissance Property Fund that targets urban development and redevelopment of affordable housing using "green" specifications from solar heating to recycled building materials. As an example of impact investments the fund had raised approximately US$175m and is targeting market rate returns, with a projected return of ~15% net of fees. As part of an on-going support of local communities, in its activities the fund is also including cultural amenities such as partnering with after-school educational providers (Bridges Ventures, 2010).

The key characteristics highlighting some differences between impact and social responsible investing are summed up in Figure 1.

Currently, most impact investments tend to operate as private undertakings. Most allocation activities in publicly tradable equities that incorporate social or environmental goals will take the form of **socially responsible investment**, in which investors seek to reduce negative effects rather than proactively create beneficial ones. However, as the market matures it is likely that broader based initiatives will become available and gain visibility.

Additionally, every investment that is supported by external capital should have precisely specified objectives orientated towards positive social or environmental impacts, and they should be clearly stated in corporate documentation (e. g. the articles of association) at the outset. The envisaged impact is most likely to be brought about via business operations and products or services engendered or facilitated by way of such investments. The business should also have a system in place to measure the impact (Bridges Ventures, 2010).

Yet, the key driver of impact investors' success is aspiration to deliver **competitive financial returns**. From investors' perspective we could say that any return on impact investment that is above a risk-free rate is satisfactory. However having said that we have to take into account impact investments' potential in generating rates of return. In this context we would expect that investments in this type of asset class would perform way above the zero risk rate and generate investor's profit, which resembles markets performance. This goal should coexist with the commitment towards positive impacts, though investors

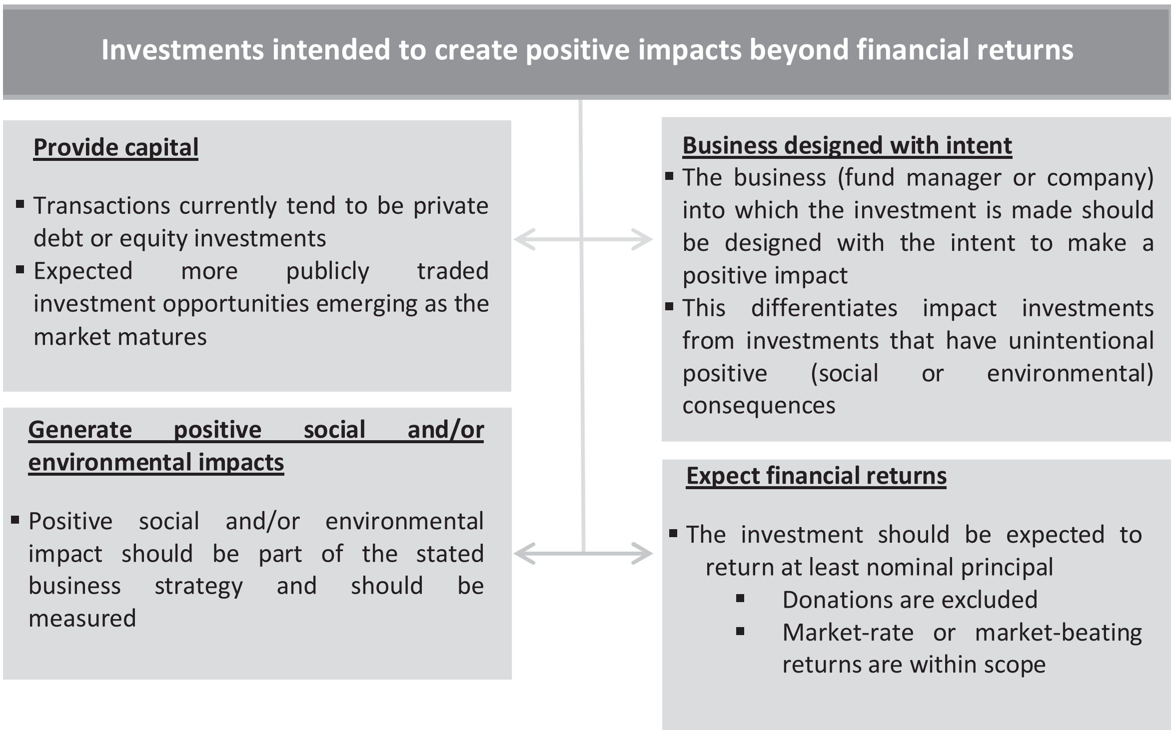


Figure 1. Defining impact investing.
Source: O'Donohoe, Leijonhufvud and Saltuk, 2010, p. 14.

might pursue varying weightings of both objectives in their overall strategies. In fact, the pairing of these two motivations by investors is possible to encourage businesses to develop in financially sustainable ways, thus facilitating the growth of the impact delivered by those businesses (O'Donohoe *et al.*, 2010).

By leveraging the private sector, impact investments can provide financings on a scale that philanthropic initiatives are unable to support. Investors in impact investment funds can include high net worth individuals (HNWIs) as well as foundations flexible enough to allocate their assets under management to a wide range of investment classes. Basing on a study by the Monitor Institute (Freireich, Fulton, 2009), participants in impact investing can be categorised by their primary motivation for investing as "**financial first**" or "**impact first**". The following figure demonstrates the segmentation of impact investors by strategic preferences.

In line with the aforementioned taxonomy, "**financial first**" investors seek to balance out financial returns with social/environmental impacts. This group tends to comprise commercial investors searching for investment vehicles offering returns implicating the opportunity cost of capital, while yielding some social/environmental benefits (Freireich, Fulton, 2009).

Conversely, "**impact first**" investors seek to combine a high proportion of social or environmental effects with some financial returns. This group promotes social/environmental good as the overriding objective and may be willing to accept a spectrum of satisfactory returns: from mere principal protection to beating predefined "hurdle rates". This group is willing to accept a lower than market rate of return in investments that may be perceived as higher risk (in order to help reach social/environmental goals that cannot be achieved in combination solely on the basis of market rates).

On occasion, both groups of investors will collaborate in what is termed as "**layered structures**" (also termed "Yin-Yang" investments). Layered structures occur when the two types of investors join forces, amalgamating capital from the "impact first" and "financial first" segments, pooling various types of investment sources with different agendas and motivations. In such deals, "impact first" investors accept a sub-market, risk-adjusted rate of return enabling other tranches of the investment to become attractive to "**financial first**" players. This symbiotic relationship permits **"financial first"** investors to achieve market rate returns, and "**impact first**" investors to leverage their investment capital, thus producing significantly more social impact than they would if investing singlehandedly (Bridges Ventures, 2010a).

The use of various financing sources development has transformed over the past decade. Capital flows derived from the private sector have gradually supplanted foreign aid and private philanthropy. Such a

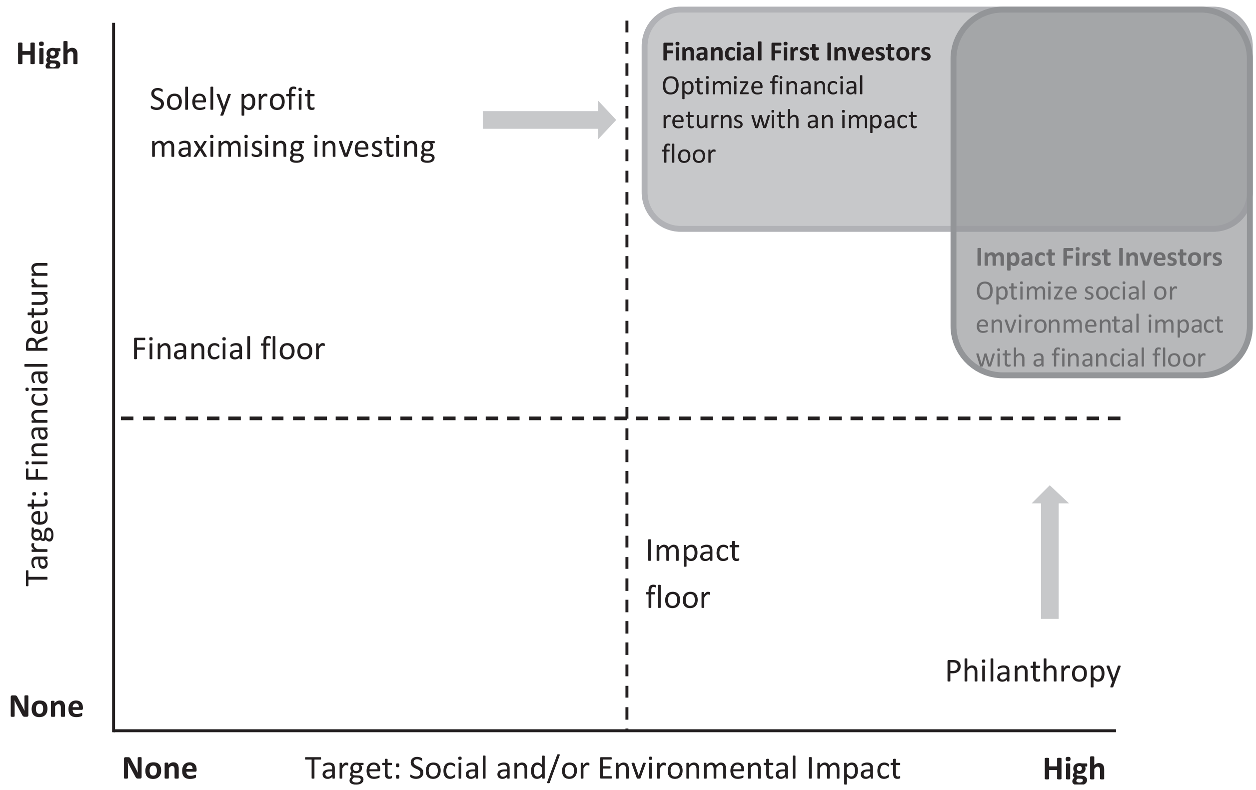


Figure 2. Impact investment value chain.
Source: Freireich, J., Fulton, K., 2009, p. 33.

tendency has also affected impact investments that have been re-orientated towards more recourse to private funding.

Despite the recent turmoil in global capital markets, the **do-good momentum** behind the impact investment process is unlikely to be as affected as are other segments of the financial industry (*inter alia* thanks to a more arbitrary decision-making process). While the basic institutional infrastructure of impact investment is still evolving, this financial class is becoming a distinctive and **sustainable** alternative to institutional investors and high net worth individuals. As its infrastructure matures and more funds consistently beat market driven hurdle rates, the impact investment segment is poised to become a powerful force able to address both significant social and environmental issues and chart a new course for the financial services industry at large.

IMPACT INVESTMENT ORIGINS AND TAXONOMY

It is fair to say that, historically, **philanthropy** served as an attempt to minimise the negative social outcomes of human poverty. As a form of donation (whether it is money, property or services), philanthropy has been instrumental in mitigating social or environmental inequalities and helping those who are unable to fend for themselves. Philanthropists have usually come from high net worth individual circles and have operated through charities seeking to combat a variety of social challenges.

Alongside philanthropy, one can also distinguish **social responsible investment** (SRI). The origins of SRI are likely to date back to 1758 when the Quaker Philadelphia Yearly Meeting prohibited members from participating in the slave trade (the buying or selling humans) (The Ethical Partnership, 2001; Quakers in Britain, 2012).

One of the earliest and most eloquent adopters of SRI was J. Wesley (1703–1791). J. Wesley's sermon entitled "The Use of Money" (2002) outlined a first set of principles behind social investing, essentially prohibiting to harm your fellow citizen while conducting your business and avoiding industries (such as chemical production), which can harm the health of workers. Additionally, it is worth pointing out that in the early days of SRI some of its prominent epitomes were strongly motivated by religious beliefs. Their advocates would try to persuade investors to avoid "**sinful**" stocks, e. g. those associated with products such as guns, liquor or tobacco. The overall history of individual investors' awareness of socially responsible capital allocation (usually avoiding exposure to predefined companies or activities whose social effects are considered negative) is thus well established (cf. Fabretti, Herzel, 2012).

The ascent of ethical investing in the 1980s gave further momentum to the development of impact investments, as did a proliferation of **corporate social responsibility** (CSR) programmes. The emergent approaches tended to challenge the longstanding concept (propagated by M. Friedman) that the sole responsibility of companies (and the goal of their shareholders) is to maximise financial returns (cf. Freidman, 1970). In sharp contrast to that notion, social investors and businesses have increasingly articulated and emphasised their varying contributions to social enhancement and promotion of sustainable environmental practices, while delivering on their financial objectives.

Since the 1980s, SRI has focused on disregarding investments whose business practices do fit in with the investor's present criteria of eligibility and favouring those compliant with such pre-established rules.

While large scale initiatives — such as portfolio diversification among eligible investments or emphasis on **environmental, social and governance** (ESG) criteria (Financial Times Lexicon, 2012) — have played substantial roles in the social investment process, less conspicuous and local initiatives have coexisted. Among them have been community investments, which have usually involved **economically targeted investments** (ETIs) (Shareholder Association for Research & Education, 2008) that channelled funding to community-orientated entrepreneurs and enterprises via local institutions — such as community development banks, credit unions or venture capital funds as well as venture lending (Strandberg *et al.,* 2004).

The unique attitude represented by social investors is centred on willingness to align their investment activity with independently defined interests, as in "**mission based investing**" (MBI) and "**programme related investing**" (PRI). Approaches like "**double**-" and "**triple bottom line**" investing (*the three bottom lines, otherwise referred to as the "three pillars" and consist of three "P"s, i.e.: **people, planet, profits**. The underlying philosophy is combining the financial, social and environmental performance of the corporation over an extended period of time*) have explicitly given evenly balanced prominence to financial and social/environmental goals (Phillips, Hager and North Investment Management, 2010).

A landmark event in the development of impact investments was the arrival and spread of **microfinance**. It gained visibility at the turn of the millennium and has since promoted socio-economic development at grassroots level by providing lending to the underprivileged. The lending is usually small and is accompanied by a repayment plan intended to deliver a modest return to the lender. As such, microfinance directs funds to social enterprises and fosters economic activity among the poorest strata of human populations in an effort to empower them and help them better handle crises and adversity (Phillips, Hager and North, Investment Management, 2010).

As social investments were gradually making a footprint on the global investment map, in 2003 J. Emerson introduced the term "**blended value investing**" (BVI) to illustrate the combination of investment and philanthropy (Godeke, Pomares, 2009). In line with this concept, BVI has offered a range of risk reward profiles and different types of social and environmental value creation models globally — while also seeking positive financial returns.

Progressively, impact investments have become to be understood in conformance with **J. Emerson's approach**, interweaving numerous investment activities with social and environmental purposes that also contained an element of financial reward (cf. Emerson, Spitzer, 2006).

Today, numerous institutions around the globe are experimenting with novel forms of investment designed to generate both competitive returns and positive social and environmental transformations. The idea of using "for profit" investment strategies for a dual purpose has shifted from the periphery of finance to its mainstream. Environmentally and socially intelligent business decisions, previously marginalised by unconvincing strategic and financial rationales, are now coming to the fore. More and more often, institutional investors are no longer asking if, they are asking how to deploy their capital.

CURRENT MARKET TRENDS AND CHALLENGES TO IMPACT INVESTING

The recent economic crises have undermined confidence in well-established investment ideologies and their ardent advocates. The emergence of impact investing provides a compelling alternative, by offering investment exposure in conjunction with a social dimension and, ultimately, by broadening the scope of investment solutions able to address global economic problems (whose magnitude and complexity continue to soar).

Beyond the pure social significance, the impact investment universe is evolving as a partial remedy to challenges progressing within the institutional management industry *per se*. These constraints relate to the unhindered expansion of **exchange traded funds** (ETFs) and index funds, an over-reliance on **algorith-**

mic (automated) **trading** and an ever more potent role of behaviourisms in investment allocations (cf. Hott, 2007). The resultant rise in intra- and inter asset correlations complicates the use of the modern portfolio theory and makes out a powerful case for diversifying into new asset classes, including impact investments (cf. Masemer, Ballin, 2012 and Ang, Bekaert, 2002).

Conventionally, capital has been allocated either to optimize risk-adjusted returns with no specific interest in social benefit, or donated to optimize social impact (with no expectation of financial return). This has now changed with the advent of impact investments. While government or philanthropic solutions will sometimes provide these goods or services (such as healthcare or education), impact investment can complement government and philanthropic capital to reach out to more people. Recognizing that charitable donations will never attain the scale needed to address global problems, impact investment introduces a new type of capital merging both motivations.

Numerous investors and financial institutions remain optimistic about the potential for growth in the impact investment market, simultaneously acknowledging that the industry is still in its infancy. As highlighted in the J. P. Morgan report (Saltuk *et al.*, 2011), its respondents believe that the number of random institutional or high net worth individual investors who currently identify and recognise impact investments has doubled over the past two years. Nonetheless, three-quarters of respondents would still describe the current impact investing market as embryonic, rather than something in the phase of rapid expansion. The following figure demonstrates the distribution of responses collected as part of this survey.

The same study has indicated that investors intend to allocate (to impact investments) a total of US$3.8bn in the 12 months following the analysis. As the following data indicate, the average and median per investor amounts total US$75m and US$25m, respectively. Interestingly enough, amounts of capital dedicated to impact investments are evenly distributed, including a single investor who planned to allocate up to US$1bn over the 12-month period. In addition, we can observe a particularly wide dispersion in the number of investments made by respondents covered by the survey.

The aforesaid data might suggest that impact investments are already widely acknowledged by financial market players and constitute a new class of alternatives to traditional capital allocation. However, the important question at this stage is whether impact investment can be referred to as a standalone class of institutional investment — to begin with.

Prior to an answer, it is important to define an asset class *per se*. Basing on a general approach, an asset class is a broad group of securities or investments that tend to react similarly in different market conditions. Individual asset classes are also routinely governed by the same rules and regulations. Oftentimes, three basic asset classes are distinguished: equity securities (stocks), fixed-income securities (debt) and cash equivalents (money market investments). Real estate, commodities and derivatives (and their combinations) are also considered asset classes by some theoreticians and practitioners (Financial Times Lexicon, 2012).

The Chartered Financial Analyst (CFA) Institute uses a definition that reflects financial characteristics of a given set of assets. From that perspective, an asset class will typically:

- include a relatively **homogeneous** set of components,
- be mutually **exclusive**,
- be **diversifying**,
- as a group, make up a preponderance of worldwide investable **wealth**,
- have the capacity to absorb a significant fraction of an investor's portfolio without seriously affecting the portfolio's **liquidity** (CFA Program Curriculum Volume 3 in O'Donohoe *et al.*, 2010).

It is clear that all the above-mentioned traditional assets such as stocks or bonds meet the conditions requisite of asset classes. The current state and nature of the impact investment market permits us to say that those undertakings also merit identification as an alternative class of assets. As undoubtedly professional in nature, impact investments require a various set of allocation exposure as well as risk management skills. In its origins, impact investing emerged from the entrepreneurial initiatives of professionals integrating the investment discipline of financial services firms with the social focus promoted by foundations and charities. While these individuals began their part time impact investing within a broader and more traditional professional practice, they increasingly started to organize themselves into distinct structures that enable dedicated attention and cultivate impact investing (O'Donohoe *et al.*, 2010).

Defining impact investments as an asset class within the alternative investment segment is most likely to spur asset growth, as historically observed in the case of hedge funds, private equity funds and commodity speculators. Recognizing impact investment as an asset class will enable asset managers and investors to develop unique skills to implement and manage impact investments, streamline their operations and develop standards and benchmarks to enhance transparency and performance.

The survey by J. P. Morgan quizzed institutional and high net worth individual investors as to their

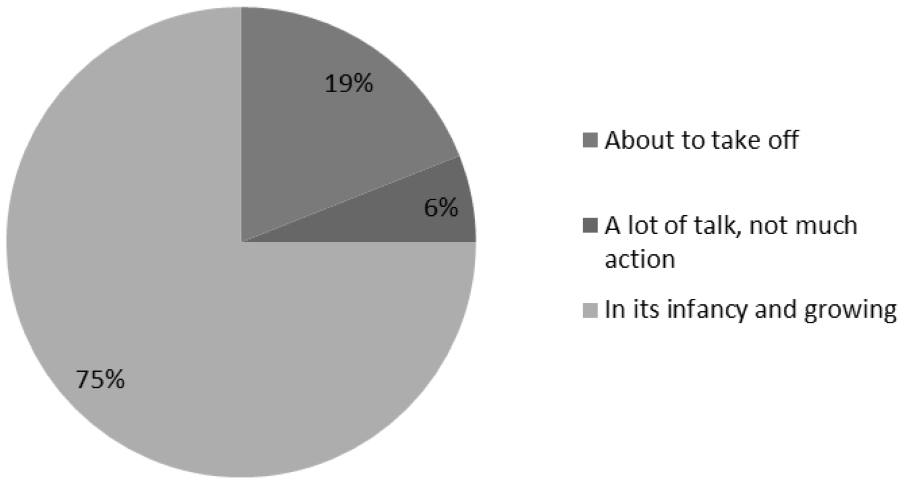


Figure 3. The current state of the impact investment market.
Source: Global Impact Investing Network, J. P. Morgan, 2011, p. 5.

approach to impact investments. For research clarity, data on impact investing have been split into the developed markets (DM) and emerging market (EM) categories.

The following figures intriguingly demonstrate how impact investors' return expectations are shaped across the developed and emerging markets, as well as broken by traditional asset classed: either debt or equity. The data show a conspicuously high variance between markets and instruments. Figure 4 portrays the distribution of return expectations for developed market debt investments, while Figure 5 does the same for emerging market debt investments. Figure 6 and Figure 7 illustrate the expectations for developed market and emerging market equity exposure.

While we can discern a much broader distribution of expectations in equity exposure than in debt allocations, the total number of investments made shows alone a greater motivation to balance strong financial returns with social impact.

One of the key characteristics of the current impact investment landscape is the small average deal size. The following figures demonstrate investment size ranges. Figure 8 shows a further breakdown of the last bar contained in Figure 9 (where deals were larger than US$5m). As evidenced by the charts, we can observe that the dominant magnitude of investments came to US$1m or less. Only 35 of the 1,105 deals reported under the survey surpassed US$10m (in notional value).

The small average size of impact investments might indicate that the market for those types of allocation is not yet fully developed. At the current stage, investments can be less liquid and incur higher costs and risks. The relatively small average deal size could result from the over-sampling of early stage impact investors (that have tended to target more socially focused businesses and have been willing and able to shoulder the relatively high transaction costs associated with small scale commitments). As impact investing matures and more institutional investors (having a bigger return appetite) climb on the bandwagon, we can anticipate a proliferation of investment fund openings, intense pooling of their capital resources (e. g. via syndication) and a larger average size of deals. The average transaction is thus set to expand, as the industry comes of age and fund vehicles facilitate larger deals (Saltuk *et al.*, 2011).

Table 1. Investment track record and pipeline as of September 2011

Size	**Planned investments for the following year** (US$m)	**Investments made since inception** (Number)
Mean	75	9
Median	25	29
Max	1,000	1,500
Min	0	2

Source: Global Impact Investing Network, J.P. Morgan, 2011, p. 5.

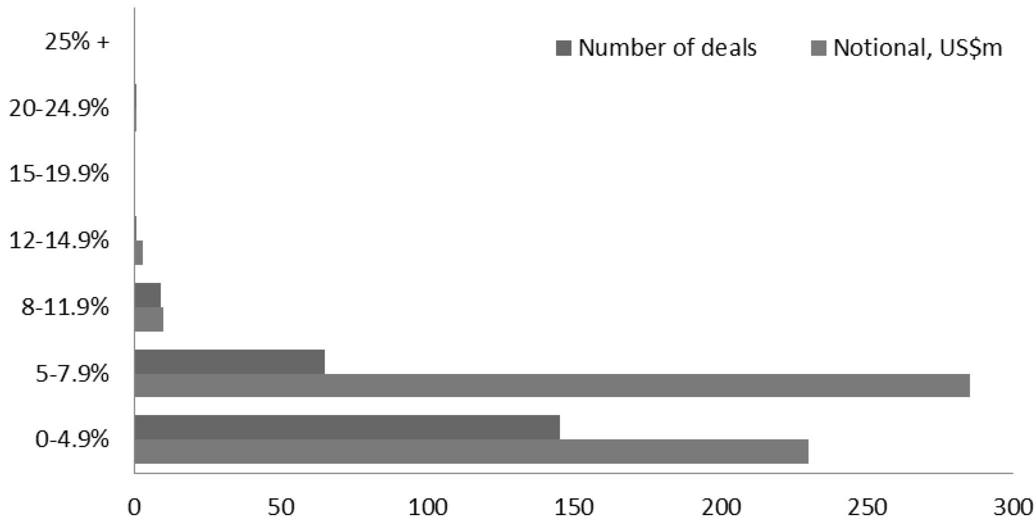


Figure 4. Expected returns — Developed markets debt investments.
Total number of investments = 219; Total size of investments = US$524m
Source: GIIN, J. P. Morgan, 2010, p. 33.

THE FUTURE OF IMPACT INVESTMENT

As aforementioned, impact investment plays a vital role in the furtherance of socially productive initiatives, so moral arguments for its future expansion are potent. However, to make it a full-fledged and viable class of institutional investment, the following prerequisites have to be addressed early on:

- **Clear-cut classification**: as in other (more established) classes of investment management there needs to be a more in-depth conceptual classification (including but not limited to percentage weightings of social and investment strategies/styles) of entities active in the impact investment community, such a move would help further define their competences and would (to a large extent) determine the success of future impact investment ventures;
- **Transparency**: historically, the impact investment business has been relatively opaque, which has hampered its growth; to attract a wide array of committed contributors from the public and private sectors, impact investment will have to upgrade its accountability with particular emphasis on information disclosure regarding impact investors' ownership composition, management structure, investment history, portfolio allocation, compensation mechanisms, busi-

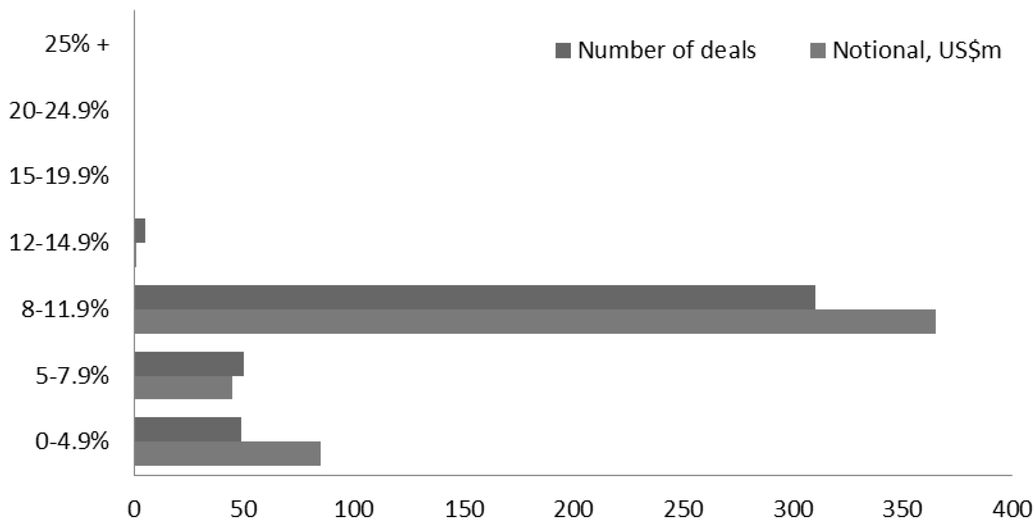


Figure 5. Expected returns — Emerging markets debt investments.
Total number of investments = 411; Total size of investments = US$488m
Source: GIIN, J. P. Morgan, 2010, p. 33.

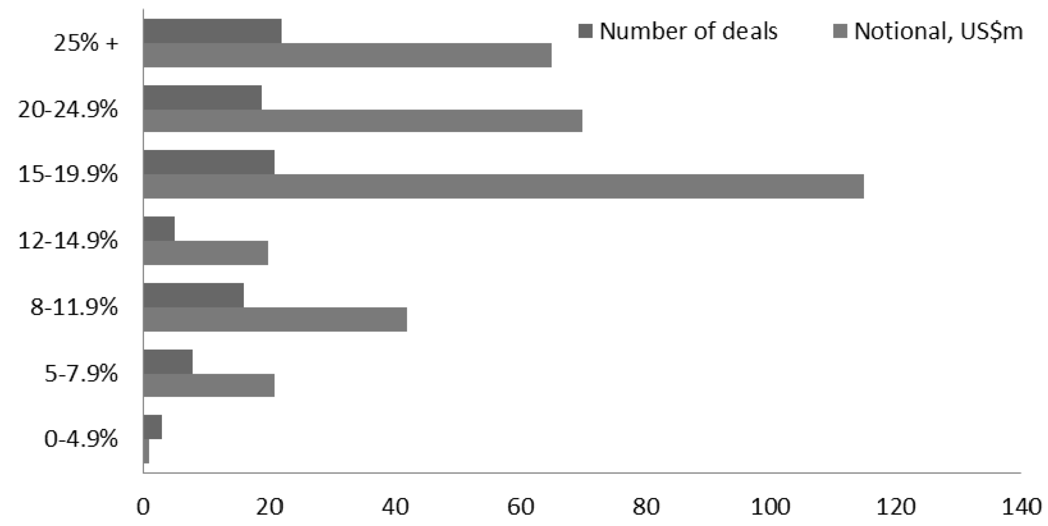


Figure 6. Expected returns — Developed markets equity investments.
Total number of investments = 91; Total size of investments = US$320m
Source: GIIN, J. P. Morgan, 2010, p. 33.

ness ethics, strategic/tactical objectives as well as potential conflicts of interest between financial and social goals; cf. the Linaburg-Maduell (sovereign wealth fund, SWF) Transparency Index (Linaburg-Maduell, 2012);

- **Reporting standards**: a critical aspect of impact investors' growing appeal to public and private capital providers is consistency and regularity in reporting composite (social and investment performance). The convenient starting point would be the adoption and promulgation of Impact Reporting and Investing Standards (IRIS) pioneered in 2011 (IRIS, 2011), however, this investment *genre* should in the long run develop a series of segment specific benchmarks (tied to the subsets broken down by percentage financial/impact proportions and categorised by social impact types) that would enable the calculation of risk and socially adjusted measures of investment efficiency (cf. Fishburn, 1977);
- **Structural and cohesion funding**: no matter how transparent, well organised and business friendly impact investors become, they run the risk of lagging behind other types of collective investment vehicles in absolute performance (for reasons of socially relevant costs that regular investors do not have to bear); in recognising the beneficial and socially constructive roles played by impact inves-

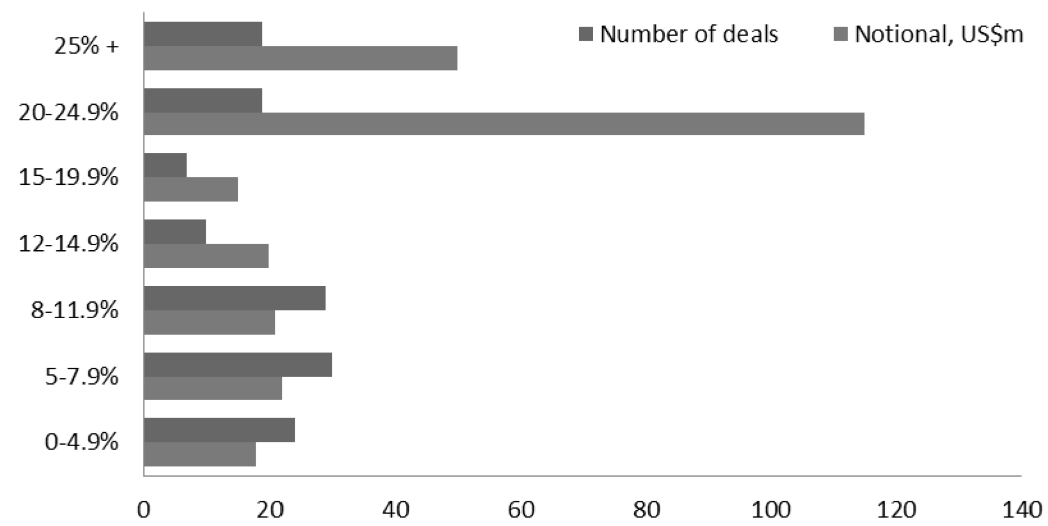


Figure 7. Expected returns — Emerging markets equity investments.
Total number of investments = 119; Total size of investments = US$265m
Source: GIIN, J. P. Morgan, 2010, p. 33.

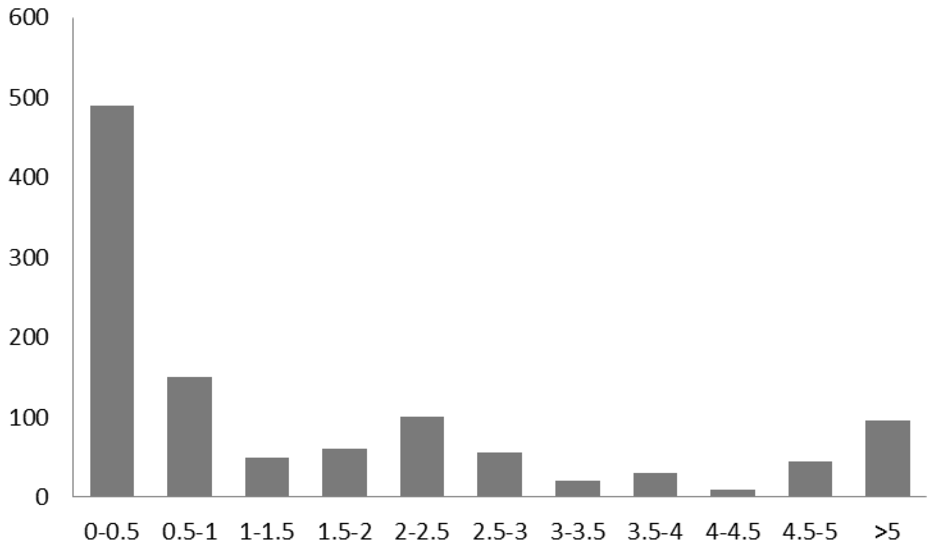


Figure 8. Distribution of investment sizes across reported investments.
Number of deals per bucket; bucket sizes shown in US$m.
Source: GIIN, J. P. Morgan, 2010, p. 35.

tors (e. g. a more efficient use of resources than in regular philanthropy), governments and international organisations should consistently support (among others via direct subsidising) their expansion;

- **Lobbying and networking**: evidently, the impact investment community has not yet achieved the global visibility and leverage needed to attract reliable capital infusions from other (more established) financial institutions that adopt socially responsible investment attitudes. Given the growing interdependence of institutional investments impact investors need to become more assertive in originating financing (also through various forms of syndication).

CONCLUSION

Impact investment, despite a relatively limited record of activity, is emerging as a promising class of financial management. Its exceptional character combines the active pursuit of social goals with a sober focus on investment efficiency. Based on the analysed characteristics we can be sure that impact investments are able not only to benefit targeted societies but provide investors with diversification, risk management and compound return producing tools. The outlook for impact investing remains optimistic (despite recurring fears of macroeconomic volatility and risk aver-

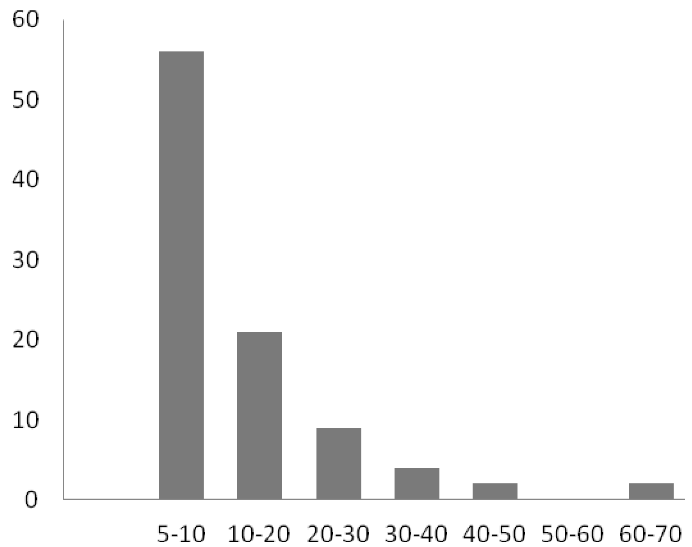


Figure 9. Distribution of the largest investments.
Number of deals per bucket; bucket sizes shown in US$m (for deals upward of US$5m)
Source: GIIN, J. P. Morgan, 2010, p. 35.

sion). Yet, to realise its full potential, impact investment needs to reform its internal organisation, achieve greater transparency and integration, as well as to promote its agenda locally and globally to policymakers and institutional investors.

REFERENCES

Ang, A., Bekaert, G. (2002). "International Asset Allocation with Regime Shifts", *Review of Financial Studies*, Vol. **15**, No. 4.

Bridges Ventures (2010) "Investing for impact: Case studies across asset classes", *GIIN* [online at: http://www.parthenon.com/ThoughtLeadership/InvestingforImpactCaseStudiesAcrossAssetClasses accessed 02.03.2012].

Bridges Ventures (2010a), "Innovative investments that make a difference", Impact Report [online at: http://www.bridgesventures.com/bridges-ventures-impact-report accessed 02.03.2012].

Emerson, J., Spitzer, J., (2006), "Blended Value Investing: Capital Opportunities for Social and Environmental Impact", *World Economic Forum*, March 2006.

Evenett, R., Richter, KH. (2011), "Making Good in Social Impact Investment", *The Social Investment Business*, p. 14, [online at: http://www.thecityuk.com/assets/Uploads/MakingGoodOnSocialImpactInvestment.pdf accessed 04.03.2013]

Fabretti, A, Herzel, S. (2012), "Delegated Portfolio Management with Socially Responsible Investment Constraints", *European Journal of Finance* (Volume **18**, Issue 3–4, Special Issue: Law, Ethics and Finance)

Financial Times Lexicon, [online at: http://lexicon.ft.com/Term?term=ESG accessed 05.03.2012].

Fishburn, P.C. (1977), "Mean-Risk Analysis with Risk Associated with Below-Target Returns", *American Economic Review*, 62–2, Nashville, TN, USA.

Freireich, J., Fulton, K. (2009), "Investing for Social & Environmental Impact, A design for Catalyzing An Emerging Industry", *Monitor Institute*, [online at: http://www.monitorinstitute.com/impact-investing/documents/InvestingforSocialandEnvImpact_FullReport_004.pdf accessed 19.04.2013].

Friedman, M. (1970), "The Social Responsibility of Business is to Increase its Profits" *The New York Times Magazine*, [online at: http://www.colorado.edu/studentgroups/libertarians/issues/friedman-soc-resp-business.html accessed 15.02.2012].

Global Impact Investment Network (2009), [online at: http://www.thegiin.org/cgi-bin/iowa/investing/index.html accessed 02.03.2012].

Godeke, S., Pomares, R. (2009), "Solutions for Impact Investors: From Strategy to Implementation", *Rockefeller Philanthropy Advisers*, [online at: http://www.rockefellerfoundation.org/news/publications/solutions-impact-investorsfrom accessed 04.03.2012].

Hott, Ch. (2007), "Herding Behavior in Asset Markets", *Journal of Financial Stability*, Vol. **5**, Issue 1.

IRIS (Impact Reporting and Investment Standards) performance data report (Edition 2011), [online at: http://iris.thegiin.org/files/iris/Data_Driven_IRIS_report_final.pdf accessed 30.05.2012].

Linaburg-Maduell (sovereign wealth fund, SWF) Transparency Index, [online at: http://www.swfinstitute.org/statistics-research/linaburg-maduell-transparency-index/ accessed 30.05.2012].

Masemer, S. and Ballin, A. (2012), "Alternative Investments: Implementation Solutions", *Quaker Funds*, p. 1–2 [online at: http://www.quakerfunds.com/sites/quakerfunds.com/files/QKAI_122011_Alts_Implementation.pdf accessed 29.05.2012]

Monitor Institute (2009), "Investing for Social & Environmental Impact" [online at: http://www.monitorinstitute.com/impactinvesting/documents/InvestingforSocialandEnvImpact_Snapshot.pdf, accessed 01.02.2012].

Myles, G. (2003), *Investment Analysis,* 2003, p. 4, University of Exeter [online at: people.exeter.ac.uk/gdmyles/Books/IA.pdf accessed 29.05.2012]

O'Donohoe, N., Leijonhufvud, C., and Saltuk, Y. (2010), "Impact Investments: An emerging asset" *J. P. Morgan Global Research*.

Pan, P., Mardfin, JK., (2001), "Socially Responsible Investing", *Legislative Reference Bureau, State Capitol Honolulu*, Hawaii, Report No. 6, 2001.

Phillips, Hager & North Investment Management (2010), "An Overview of Impact Investing"*, RBC Global Asset Management Inc*.

Power Management Institute (2011), [online at: http://pmintpc.com/ accessed 01.02.2012].

Quakers in Britain, [online at: http://www.quaker.org.uk/early-colonial-quakers-protest-against-slavery accessed 05.03.2012].

Saltuk, J., Bouri, A. and Leung, G. (2011*), "*J.P. Morgan — Social Finance Insight into the Impact Investment Market", *Social Finance Research*.

Shareholder Association for Research & Education (2008), "Putting Responsible Investment into Practice — A Toolkit for Pension Funds, Foundations and Endowments", 2008, p. 11, [online at: http://www.share.ca/files/RI_Toolkit_WEB.pdf accessed 21.02.2012].

Sharpe W. *et al.* (2011), "Capital Market Expectations, Market Valuation, and Asset Allocation". *CFA Program Curriculum Volume 3, Level III* [in:] O'Donohoe, N., Leijonhufvud, C., and Saltuk, Y. (2010), "J.P. Morgan, Impact Investments An emerging asset class", *J. P. Morgan Global Research*.

Strandberg, Coro and Cameron, S. (2004), "The Emergence of Community Investment as a Strategy for Investing in your Community" *Investing in Your Community conference Saskatchewan*, March 2004, p. 6–7, [online at: http://www.agcouncil.ca/pdf/CommunityInvestment1.pdf accessed 21.02.2012].

Simon, J. and Barmeier, J. (2011), "More than Money: Impact Investing for Development", *Centre for Global Development*.

TD Direct Investing (2010), [online at: http://www.tddirectinvesting.co.uk/get-started/guide-to-investing/ accessed 27.05.2012].

The Ethical Partnership, [online at: http://www.the-ethical-partnership.co.uk/historyofethicalinvestment.htm accessed 28.05.2012].

Viviers, S. (2009), "Responsible Investing in South Africa", *Investment Analysts Journal* No. **69.**

Wesley, J. (2002), "The use of money a sermon", [online at: http://www.whatsaiththescripture.com/Text.Only/pdfs/The_Use_of_Money_Text.pdf accessed 20.02.2012].

Cycle-Adjusted Capital Market Expectations under Black-Litterman Framework in Global Tactical Asset Allocation*

Anna MIKAELIAN
International Finance Faculty, Financial University, Moscow
3700826@gmail.com

Abstract. We propose an implementation of Black-Litterman allocation approach with views based on time-varying risk premiums during different phases of business cycle. To obtain views we define 5-phase business cycle taken from US economic history 1979–2012. Then we formulate stylized facts on assets classes' co-movement during different phases of business cycle and set simplistic rules for generating views based on mentioned facts. To predict phase of cycle we use methodology of 5-phase business cycle prediction based on key macroeconomic indicators analysis. We back-test both approaches and compare them to such classical asset allocation strategies performance, as market-equilibrium portfolio, equal-weighted "naive" diversification, 60/40 and other. We find that Black-Litterman allocation shows superior performance to almost all other allocation strategies during 1980–2011 years.

Аннотация. Вашему вниманию представлено внедрение модели Блэка-Литтермана с входящими данными в виде взглядов относительно доходностей различных классов активов в зависимости от фаз бизнес-цикла. Для формирования этих взглядов мы воспроизводим 5 фаз бизнес-цикла экономики США периода 1979–2012 гг. Далее мы выявляем закономерности динамики классов активов в разные периоды цикла и устанавливаем простые правила формирования взглядов, основанных на этих закономерностях. Для прогнозирования фазы цикла мы используем методологию 5-фазного бизнес-цикла, основанного на анализе ключевых макроэкономических показателей. Мы тестируем оба подхода модели и сравниваем ее с такими классическими стратегиями, как рыночный портфель, равно-взвешенная диверсификация, 60/40 и др. Мы считаем, что диверсификация активов методом Блэка-Литтермана превосходит практически все рассмотренные стратегии в период времени с 1980 по 2011 г.

Key words: Black-Litterman, Markowitz, MVO, MPT, Bayesian prior, posterior, asset allocation, business cycle, Fed recession indicator.

INTRODUCTION

The efficiency of asset allocation strategies is one of the core topics of modern financial science at least since seminal work of Brinson *et al.* (1995) and series of subsequent researches written since then. An evidence of evergreen relevance of this topic is well-known research by Faber (2007), Meucci (2005, 2010), Bekkers *et al.* (2009), which became one of the most-downloaded research papers on SSRN. Despite well-known flaws in Markowitz approach and theoretically better performance exhibited by Black-Litterman portfolios, no attempt has been made to test and compare historical performance of both approaches in Faber (2007) and Bekkers *et al.* (2009) style.

The mean-variance optimization (MVO) created by Markowitz became the most widely-used technique for making investment and asset allocation decisions. The essence of MVO is to create the efficient frontier — the set of most optimal portfolios at a given return or level of risk, using historical returns of an asset class. Unfortunately, when investors have tried to use this model, they faced some problems. The main problem of classical Markowitz and his MVO is that the results received are usually unreasonable. They occur when, having no constraints, the model chooses large short positions in many assets, and when constrained, it often prescribes "corner" solutions with zero weights in many assets and unreasonable large weights of assets with small capitalization. Thus, the portfolios formed by the MVO are unintuitive and highly concentrated.

Such nature of results is caused by two main problems. First, expected returns are very difficult to esti-

* Учет фаз бизнес-циклов в формировании ожиданий доходности рынков при глобальном тактическом распределении активов в соответствии с моделью Блэка-Литтермана

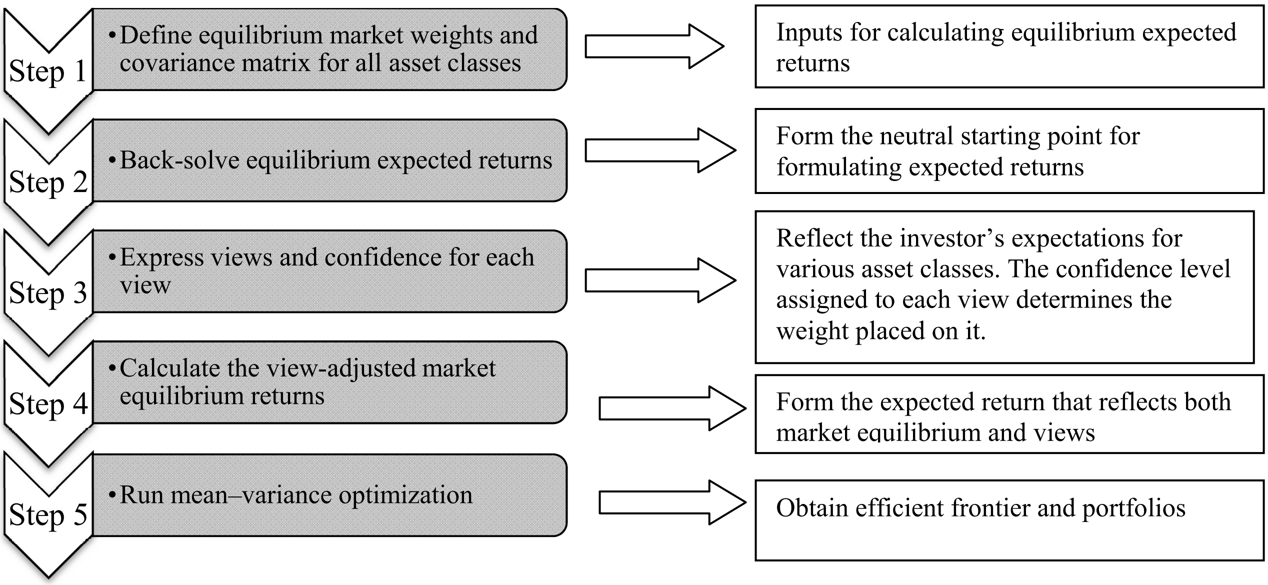


Figure 1. Steps of the Black-Litterman Model*.
Source: Maginn, J. L. (2007), "Managing investment portfolios: a dynamic process", Wiley and Sons.

* *See more detail and theoretical background of the Black-Litterman model in Idzorek, Thomas, "A Step-By-Step guide to the Black-Litterman Model, Incorporating User-Specified Confidence Levels.", Meucci, Attilio, "The Black-Litterman Approach: Original Model and Extensions."*

mate and the historical returns used by investors for this purpose provide poor guides to future returns. Second, the optimal portfolio asset weights and currency positions of MVO asset allocation are very sensitive to the return assumptions used. And these two problems compound each other. The model is not able to sort out confident and certain views from simple assumptions and the portfolio it generates has usually a little or even no relation to the views that investor wishes to express.

In order to avoid these problems, Fischer Black and Robert Litterman developed another quantitative approach, known as the Black-Litterman asset allocation model. The Black-Litterman model was first published by Fischer Black and Robert Litterman of Goldman Sachs in an internal Goldman Sachs Fixed Income document in 1990. Their paper was then published in the *Journal of Fixed Income* in 1991. A longer and richer paper was published in 1992 in the *Financial Analysts Journal* (FAJ). The model was then discussed in greater details in Bevan and Winkelmann (1998), He and Litterman (1999), Satchell and Scowcroft (2000), Litterman (2003), Idzorek (2004) and Walters (2008). Various applications and extensions of the model were discussed in Beach & Orlov (2007), José Luis Barros Fernandes (2011), Meucci (2010).

The Black-Litterman model combined the CAPM by Sharpe (1964), reverse optimization by Sharpe (1974), mixed estimation by Theil (1971, 1978), the universal hedge ratio/Black's global CAPM by Black (1989) and Litterman (2003), and mean-variance optimization of Markowitz (1952). The model is aimed to overcome the problems of unintuitive, highly-concentrated portfolios, input-sensitivity, and estimation error maximization. It provides both an intuitive portfolio and a clear way to specify investors' views and to blend the investors' views with prior information. The steps of the Black Litterman approach are shown in Figure 1.

But the quite obvious from the first sight conclusion of the Black-Litterman's superiority over the classical Markowitz is not such unambiguous and non-doubtful. It results in more intuitive, diversified portfolios, and most importantly has an opportunity of adding capital market expectations (CME).

First of all, it should be recognized that the process of generating the CME is rather subjective and it is not evident that adding such expectations improves the portfolio performance. The other problem is that no clear understanding exists regarding the validity and relevancy of the historical back-testing within the Black-Litterman or any other model as a tool of portfolio performance estimation. Some other questions and uncertainties are added up with the peculiarities and characteristics of modern financial markets where in addition to traditional debts and equities, a wide variety of alternative asset classes and financial instruments are represented. In other words, it is not unquestionable that the Black-Litterman with its all above-mentioned advantages is able to outperform other strategies in its risk and return characteristics.

METHOD

The main idea of this research is to assess the Black-Litterman model, its capability to fulfill the initial purposes incumbent on it and to create better performing portfolios in modern financial markets' conditions. The testing is to be implemented in several stages as follows:

1. Develop mechanical method of generating CME;
2. Find the source of "ideal post-hoc" CME, which supports us with such expectations as if we had a perfect knowledge about the existing and future market conditions. This source is needed because a high probability of mistakes exist when the expectations are developed by using the above-chosen mechanical method; using the "ideal" CME we will have an opportunity to assess the confidence of the mechanical method;
3. Test the classical Markowitz, the Black-Litterman without views, the Black-Litterman with "ad hoc" and "post hoc" views and other classical alternative strategies of asset allocation, based on the historical dataset. Among other strategies tested there are simple 60/40 stock/bond allocation, adapted 60/40 allocation, based on the market capitalizations weights allocation (market portfolio), equally-weighted allocation.

The main assumption of the research is that the fundamental macro-indicators, showing the stage of the business cycle in where the economy is at a point of time, are the main sources of CME. It is generally known that different asset classes act differently depending on the phase of the business cycle. Thus, to generate CME we should define the patterns of asset classes' behavior in different phases of business cycle.

The research is limited by the time horizon and the country analyzed. The testing will be done for the US national economy and financial markets, the time horizon is 33 years (since 1979). Asset classes and their proxies used in testing are as follows:

Domestic fixed income:

- Government bonds — 10-Year Treasury Constant Maturity Rate;
- Corporate bonds — Moody's Seasoned AAA Corporate Bond Yield;

Domestic equity:

- Large-caps — S&P 500 Total Return Index;
- Small-caps — Russell 2000 Total Return Index;

Commodities — S&P Goldman Sachs Commodity Total Return Index;

Real estate — NAREIT US Real Estate Return Index;

Gold — historical gold prices.

BUSINESS CYCLE

We analyzed the United States business cycle and connected its phases to the asset classes' returns and risks, trying to find the relation between the economy conditions, caused by the business cycle phase, and the asset classes' risks and returns during that phase. The time horizon analyzed was divided according to the phases of business cycle based on two main indicators: the NBER Recession Indicator and the Term Spread between long and short-term FED rates.

The NBER-based division has 5 phases — initial recovery, early upswing, late upswing, slowdown and recession. To find the beginning and ending points of these phases we took quarterly time series of US GDP growth rates, Output Gap, CPI, Sentiments, Initial Claims, Payrolls and NBER Recession Indicator. But this method of division is good only in historical testing, as its main indicators are lagging.

The second method, based on Term Spread, tries to predict the business cycle phases. This method is very hypothetical, because no single interpretation of the term spreads' values exists. Thus, we made our own assumptions of interpreting the probability values (which are the main concept of the method) in business cycle predicting. For each of these methods separate sets of views were developed (for more details see Appendix 1).

CREATING SPECIFIC INPUTS FOR BLACK-LITTERMAN MODEL

Views. As mentioned above, we have analyzed the business cycle of US to derive views about asset classes' behavior during its different phases. Using two methods (the NBER Recession Indicator-based and the Term Spread-based) we divided the US economy history into periods of different business phases. As a result, we have two types of business cycle divisions, so we will have two sets of views correspondingly.

Also, we made the assets classes' analysis over the same time horizon (1979–2012). In order to generate views for the Black-Litterman, we must combine that analysis with the business cycle divisions. It means that now we must analyze assets' quarterly returns and risks with respect to the phases of business cycle. In other words, we must find out the regularities in assets classes behavior over the cycle phases, formulate them and explore as a way of constructing more effective portfolio.

Table 2 contains mean quarterly returns and standard deviations for each NBER Recession Indicator–based business cycle phases.

We can now see that *in Recessions* Russell has the greatest return (5.57%), while the S&P GSCI has

Table 2. Asset Classes Mean Returns and Standard Deviations in Different Phases of the US Business Cycle.

Asset Class	rec		initial recovery		early upswing		late upswing		slow down	
	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
10-Y Bonds	2.00%	1.07%	1.77%	0.82%	1.66%	0.81%	1.63%	0.44%	2.19%	0.87%
AAA	2.35%	0.90%	2.09%	0.70%	1.95%	0.70%	1.88%	0.41%	2.42%	0.71%
SP500	1.40%	11.53%	2.82%	8.77%	3.47%	5.89%	4.48%	6.60%	-2.95%	6.57%
Russell	5.57%	15.11%	6.72%	10.42%	4.14%	8.11%	3.29%	9.05%	-3.44%	9.50%
Gsachs	-3.11%	18.10%	2.07%	6.92%	2.68%	6.92%	3.26%	9.83%	5.28%	17.26%
Gold	0.39%	9.44%	0.38%	7.44%	1.20%	4.95%	1.71%	6.53%	5.16%	16.14%
NAREIT	2.00%	15.21%	6.36%	6.25%	3.91%	5.12%	2.70%	6.74%	-1.50%	5.75%

a maximum negative return and a highest standard deviation (18.10%). Rationally it can be explained by existence of risk-seeking investors, who are trying to get high returns and are ready to take risk even during recession, and are choosing Small-caps as the one having less of standard deviation and high rate of return.

In the Initial Recovery REITs are totally beating Gold as during last cycles the economy started its recovery with the growth of the real estate market.

As for *the Early Upswing* the Russell is outperforming S&P500, which is an evidence of growing confidence and a desire to switch to equities as more risky assets in order to have greater returns. *The Late Upswing* is characterized by the same sentiments but with the desire to switch to less risky equities, which is S&P 500. Thus, in Late Upswing Large-caps have higher returns than Small-caps. Summarizing all the above ideas, the following views are specified in Table 3.

The figure under each view is an absolute measure of the view. Thus the first view asserts that *in Recession* Russell's quarterly return is 8% greater than the one of S&P GSCI.

The same views will be used to the business cycle phases' breakup under the Term-Spread method. Nevertheless, the final views' vectors under different methods of business cycle breakup will differ from each other due to the differences in the breakups.

Market capitalizations. Using the market capitalization weights in asset allocation is one of the main distinctions of the Black-Litterman model from classic Markowitz. As we are analyzing the period since 1979, we must back-up each asset class' market-cap history for the same time horizon. The market capitalization history dataset is rather difficult to find. Mainly, the sources give annual data, which is not matching our criteria of quarterly time series. The mission is complicated not only by the long and quarterly frequency history needed, but also by the fact that such asset classes as bonds and gold do not have a clear measure of their market capitalizations. Taking all this into consideration, the quarterly time series of asset classes' market capitalizations since 1979 till 2012 has been derived by following ways:

- The market capitalization of S&P500, Russell 2000 and FTSE NAREIT are calculated having at least one market cap value of the index at any moment of time horizon since 1979;
- The market capitalization of 10-Year Treasuries and AAA Corporate Bonds is measured by the value of open market interest;

Table 3. The Views Regarding the Asset Classes' Returns

Asset Classes	Recession	Initial Recovery	Early Upswing	Late Upswing	Slowdown
10-Y Bonds					
AAA					
SP500			RUSS > SP 1.5%	SP > RUSS 1.5%	
Russell	RUS > GSachs 8%				
Gsachs					
Gold		REIT > GOLD 6%			GOLD > REIT 6%
NAREIT					

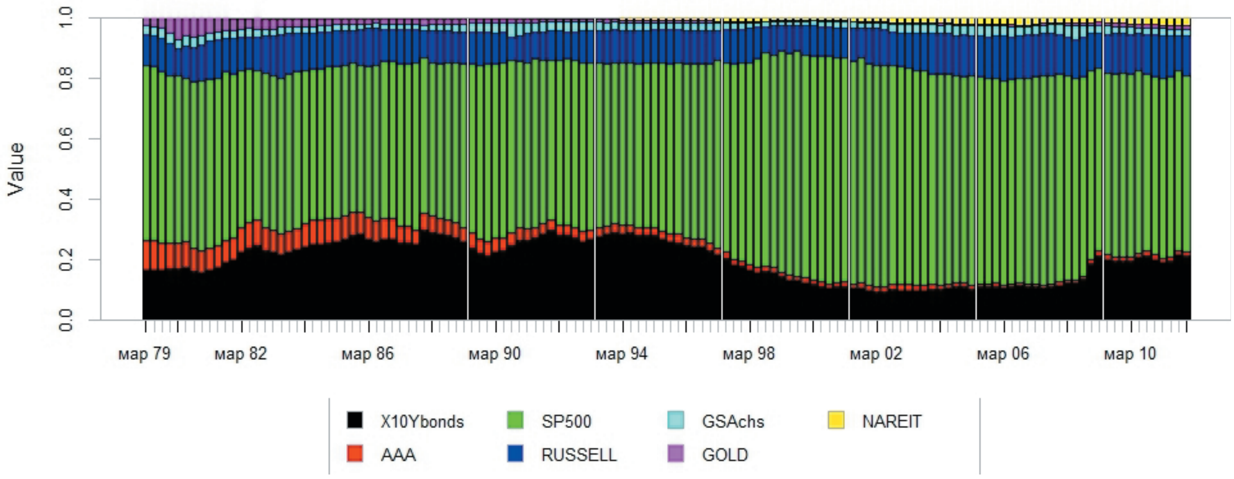


Figure 2. Historical Weights of Market Portfolio.

- As a measure of the gold's market capitalization the value of the total investable gold of US institutions is taken;
- The market capitalization of S&P GSCI is calculated by taking its structure at any moment of time. Having the weights of its constituents at a given moment, the value of open interests and the price of each futures contract, the market capitalization is estimated for that date. Then the same procedure is done with the S&P 500 and other simple price indexes.

Input assumptions and constraints. In addition to views specified, the Black-Litteman needs other input assumptions. For our Black-Litterman portfolios the following assumptions and constraints have been set:

- The value of parameter $\tau = 0{,}025$;
- Trading only long, no short positions allowed;
- The risk-free interest rate is zero;
- The starting point is the 27-th quarter of the period analyzed (1986 quarter 1). This assumption is made in order to supply the models with some history of returns as an input.

Having the historical returns, market capitalizations, views and assumptions, we can form all the Black-Litterman portfolios.

THE PORTFOLIOS PERFORMANCE ANALYSIS

In our testing we will compare the Black-Litterman portfolios with the ones of Markowitz, Market portfolio, Equally-weighted portfolio, simple 60/40 stock/bond portfolio, adapted 60/40 stock/bond portfolio.

The Black-Litterman model allows us to construct two types of portfolios: with views specified and without any views. At the same time the Black-Litterman portfolio without views differs from classical Markowitz as it takes into consideration the market capitalization weights of each asset class in the portfolio and uses equilibrium returns.

For our test we will use both these approaches and create two groups of ***Black-Litterman portfolios:***

- The Black-Litterman Equilibrium Returns portfolios without views;
- The Black-Litterman with views specified portfolios. As we have two series of views (NBER-based and FED rates spread-based) the Black-Litterman portfolio with views will be divided into two groups:
  - The NBER-based views Black-Litterman;
  - The Fed-based views Black-Litterman;

From the variety of portfolios on the efficient frontier for each type of Black-Litterman model we will take 5 portfolios:

- the minimum risk portfolio (minrisk);
- the maximum risk portfolio (maxrisk);
- the medium risk portfolio (midrisk);
- the middle between minimum and medium risk portfolio (minmidrisk);
- the middle between medium and maximum risk portfolio (midmaxrisk);

Such choice of portfolios will simplify further analysis of the models by comparing corresponding risk-level portfolios created by different asset allocation models and define which of them is better at different risk levels.

The same method is used in ***Markowitz' portfolios,*** which will also be subdivided by the risk interval.

The Market Portfolio is the portfolio which allocates asset classes basing on their market capitalizations. The weight of an asset class is determined by the ratio of its market capitalization to the total market capitalization. The reallocations are also done with respect to changes in market capitalizations.

A 60/40 stock/bond asset allocation is appropriate or at least is a starting point for an average inves-

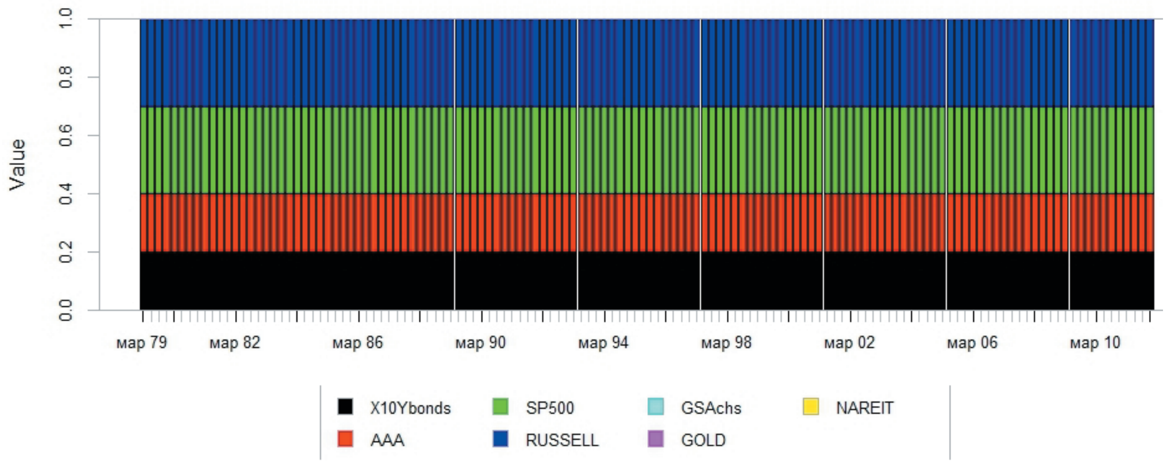


Figure 3. Historical Weights of Simple 60/40 Stock/Bond Portfolio.

tor's asset allocation. From periods predating modern portfolio theory to the present, this asset allocation has been suggested as a neutral (neither highly aggressive nor conservative) asset allocation. The equities allocation is viewed as supplying a long-term growth foundation, the fixed-income allocation as supplying risk-reduction benefits. If the stock and bond allocations are themselves diversified, an overall diversified portfolio should result.

Our 60/40 portfolio will consist of:

- S&P500 and Russell 2000 each with the weights of 30%, summing up to 60% of stocks;
- 10-Year Government and AAA Corporate Bonds each with the weight of 20%, giving 40% of bonds.

An adapted 60/40 stock/bond asset allocation differs from the simple 60/40 only by switching the regimes to 60/40 bond/stock asset allocation when being in recessions. Thus the portfolio is decreasing its risk due to dangerous economic conditions, choosing less risky assets.

Equally-weighted asset allocation gives equal weights to each other class and doesn't make any reallocations. As we have 7 asset classes, each of them will constitute a 14.3% part of portfolio.

The performance of the created portfolios is measured by the values of Sharpe, Sortino, Sterling ratios and by the Maximum drawdown. ***Sharpe ratio*** is defined as a portfolio's mean return in excess of the riskless return divided by the portfolio's standard deviation. In finance the Sharpe Ratio represents a measure of the portfolio's risk-adjusted (excess) return. ***Sterling ratio*** is defined as a portfolio's overall return divided by the portfolio's maximum drawdown statistic. In finance the Sterling Ratio represents a measure of the portfolio's risk-adjusted return.

Sortino ratio is s ratio developed by Frank A. Sortino to differentiate between good and bad volatility in the Sharpe ratio. This differentiation of upwards and downwards volatility allows the calculation to provide a risk-adjusted measure of a security or fund's performance without penalizing it for upward price changes. The values of all the listed indicators for each type of portfolio are represented in Appendix 1.

We can see that at a ***minimum risk level***, the

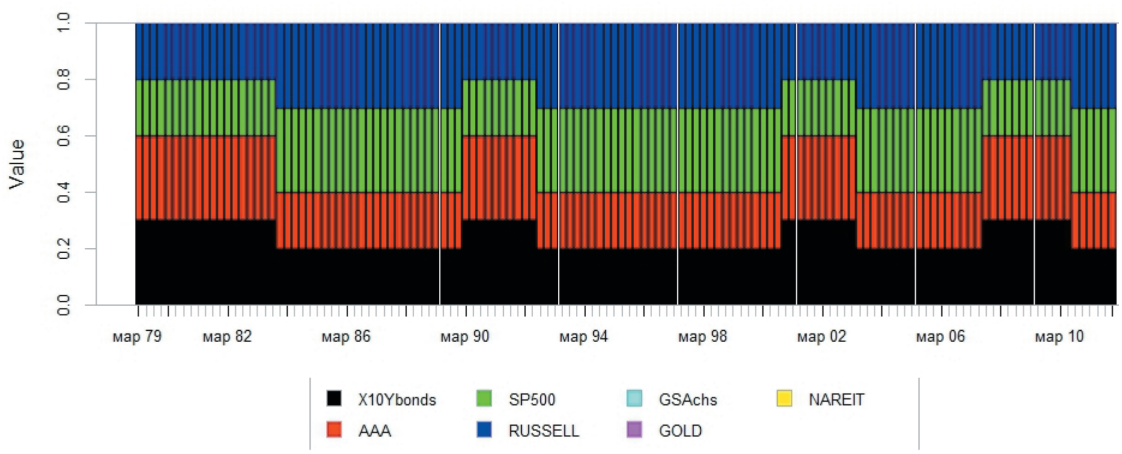


Figure 4. Historical Weights of Adapted 60/40 Portfolio.

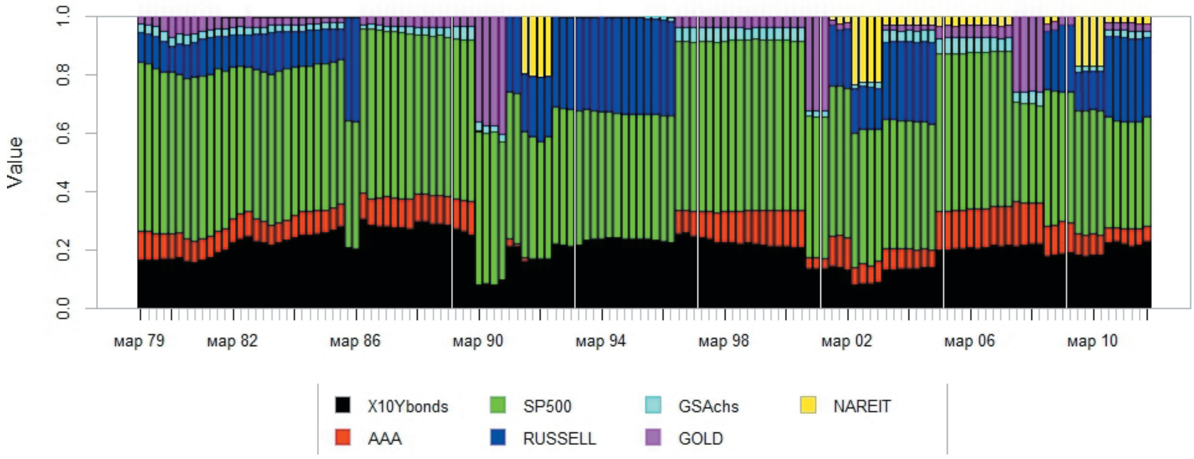


Figure 5. Historical Weights of the Minimum-Risk Black-Litterman with NBER-Based Views Portfolio.

Black-Litterman portfolios have much better results than any other in all the ratios. It is also evident that Black-Litterman portfolios do not differ between themselves in their performances, showing almost absolutely equal ratios for each of three portfolios. Figure 5 illustrates the minimum-risk Black-Litterman with NBER-based views.

At a ***min-mid risk level*** two portfolios are competing: the Markowitz and the Black-Litterman with Fed-views. The Markowitz has a greater Sharpe ratio and smaller Drawdown, the Black-Litterman has better Sortino and Sterling ratios. Figure 6 illustrates these portfolios:

The Markowitz portfolio is rather concentrated and almost totally invests into bonds as a low-risk asset. The Black-Litterman is much more diversified, which is an advantage. All else is equal.

At a ***mid-risk*** both of Black-Littermans with views show good results, just a little yielding the Markowitz in Sortino ratio. FED-based Black-Litterman has better Sortino and Sterling ratios and lower maximum drawback, while the NBER-based is succeeding in Sharpe ratio. As the Fed-based portfolio has better results in three out of four parameters, it is the best choice among the mid-risk portfolios. Figure 8 plots the returns of this portfolio over time horizon.

Moving to the ***mid-max risk*** the Black-Litterman with both types of views again are almost equally outperforming equilibrium Black-Litterman and Markowitz. But starting from this level of risk, the portfolios, which are not considering the market capitalizations (simple and adapted 60/40, equally-weighted portfolios) start to beat the Black-Litterman portfolios significantly. Markowitz' portfolios have been beaten by them since mid-risk level.

At the ***max-risk*** the tendency is strengthening and both of the Black-Litterman portfolios with views in their performance become to be equal to the simple market portfolio, again significantly beaten by both of 60/40 and Equally-weighted portfolios.

Figure 9 plots all portfolios and asset classes using their annualized values of risks and returns. The three lines on the plot correspond to the Sharpe ra-

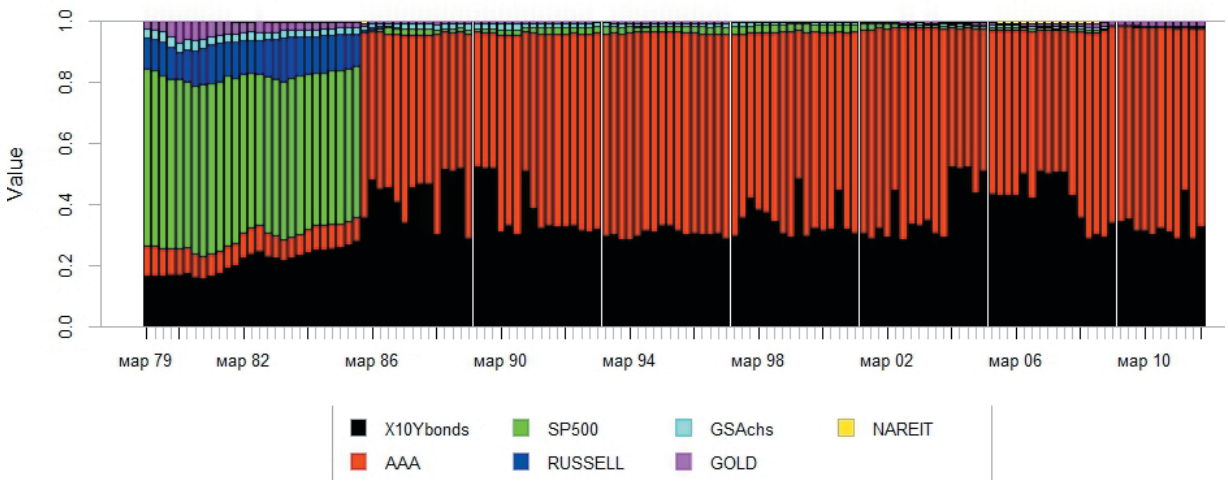


Figure 6. Min-Mid Risk Markowitz Portfolio.

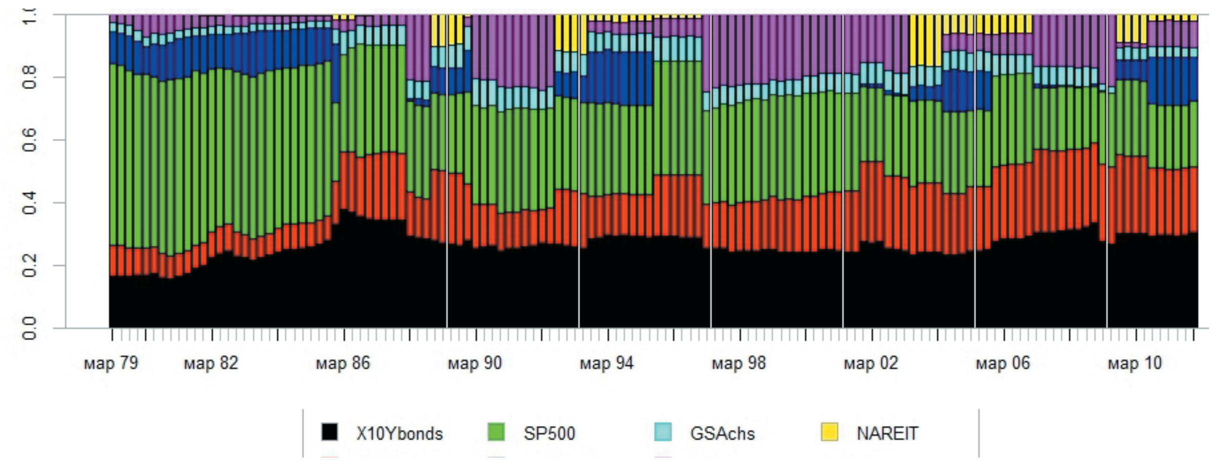


Figure 7. Min-Mid Risk Black-Litterman with FED-Based Views Portfolio.

tios. The left line is the line of Sharpe ratio = 3, the middle –2 and the Sharpe ratio of the right line is equal to 1.

From the Figure 9 we may conclude that the Black-Litterman portfolios of the min-mid risk have almost equal risk/return and thus the same attractiveness. The higher risk level portfolios of Black-Litterman and Markowitz show that the NBER-based Black-Litterman has the highest return level. The Markowitz with the same level of risk shows lower returns that an equilibrium Black-Litterman.

GENERAL CONCLUSIONS

1. *At the minimum risk level the views are not significant.* All of three Black-Litterman portfolios are beating other portfolios and are more effective and diversified. The values of all the ratios are almost equal for Black-Litterman models with views and without them, which means that views specified do not play a significant role at the minimum level of risk;

2. *With the increase of the risk level the significance of views increases too*. At the min-mid and mid-risk levels the Black-Litterman portfolios with views start to show much better results than the Black-Litterman without ones;

3. *At the middle risk levels the NBER-based Black-Litterman model is the most effective portfolio;*

4. *At the high risk levels the portfolios not based on market capitalization show better results.* Passing the mid-max point, the performance of the Black Litterman portfolios starts to decline. At this level of risk the portfolios, which do not take the market capitalization (adapted 60/40, equally-weighted and simple 60/40) start to beat the Black-Litterman portfolios;

5. *At the highest level of risk the Black-Litterman portfolios are similar by their performance to the simple market portfolio;*

6. *The Black-Litterman model beats Markowitz MVO at any level of risk;*

7. *The Fed term spread method is a precise tool for business cycle predicting.*

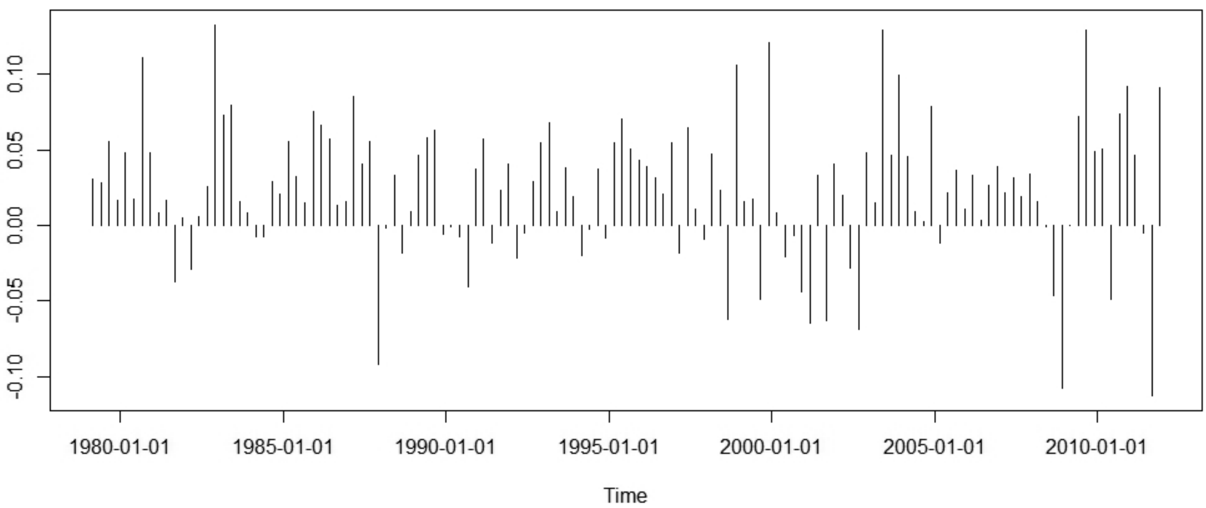


Figure 8. Mid-Risk FED-Based Black-Litterman Portfolio's Historical Returns.

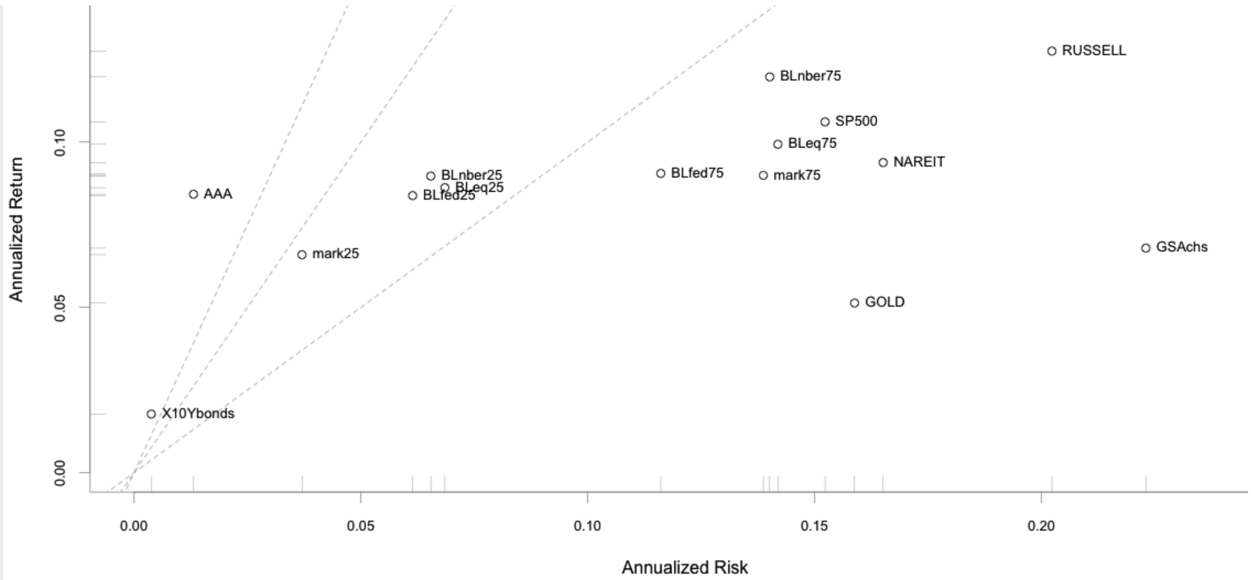


Figure 9. Annualized Assets' Risk/Ratio.

REFERENCES

Ammann, M. & Zimmerman, H. (2001), "Tracking Error and Tactical Asset Allocation", *Financial Analysts Journal* **57** (2).

Beach, S.L. & Orlov, A.G. (2007), "An application of the Black–Litterman model with EGARCH-M-derived views for international portfolio management", *Financial Markets and Portfolio Management* **21** (2), 147–166.

Bekkers, N., Doeswijk, R. & Lam, T. (2009), "Strategic asset allocation: Determining the optimal portfolio with ten asset classes", *Available at SSRN 1368689*, 1–33.

Bevan, A. & Winkelmann, K. (1998), "Using the Black-Litterman Global AssetAllocation Model: Three Years of Practical Experience." *Fixed Income Research*, Goldman, Sachs & Company, December 1998.

Black, F. & Litterman, R. (1992), "Global Portfolio Optimization, *Financial Analysts Journal* **48**, 28–43.

Black, F. (1993), "Beta and return", *Journal of Portfolio Management* **20**, 8–18.

Black, F. (1972), "Capital Market Equilibrium with Restricted Borrowing", *Journal of Business* **45** (3), 444–455.

Black, F., Jensen M. C. & Scholes, M. (1972), *The Capital Asset Pricing Model: Some Empirical: Tests. Studies in the Theory of Capital Markets*, New York: Praeger Publishers.

Brinson, G.P., Hood, L.R. & Beebower, G.L. (1995), "Determinants of portfolio performance", *Financial Analysts Journal*, 133–138.

Campbell, J. & Shiller, R. (1991), "'Yield Spreads and Interest Rate Movements"", *Review of Economic Studies* **58** (3), 495–514.

Chatrath, A. & Liang, Y. (1998), "'REITs and Inflation: A Long-Run Perspective"", *Journal of Real Estate Research* **16** (3).

Chow, G., Jacquier, E., Kritzman, M. & Lowry, K. (1999), "Optimal Portfolios in Good Times and Bad", *Financial Analysts Journal* **55** (3), 65–73.

Christopherson, Jon, and Paul Greenwood, ""Equity Styles and Why They Matter."" *Journal ofInvestment Consulting*. Vol. 1, No. 1: 21–36, 2004.

Estrella, A., Mishkin, F. (1988), "Predicting U. S. Recessions: Financial Variables as Leading Indicators", *Review of Economics and Statistics* **80** (1), 45–61.

Faber, M.T. (2007), "A quantitative approach to tactical asset allocation", *Journal of Wealth Management*.

Fama, E. & French, K. (1988), "Business Cycles and the Behavior of Metals Prices", *Journal of Finance* **43** (5), 1075–1093.

Fama, E.& French, K. (1992), "The Cross-Section of Expected Stock Returns"", *Journal of Finance* **47** (2), 427–465.

Fama, E. & French K. (1996), "Multifactor Explanations of Asset Pricing Anomalies", *Journal of Finance* **51** (1), 55–84.

French, K. & Craig W. (2003), "The Treynor Capital Asset Pricing Model", *Journal of Investment Management* **1** (2), 60–72.

He, G. & Litterman, R. (1999), "The Intuition Behind Black-Litterman Model Portfolios", *Goldman Sachs Asset Management Working paper*.

Idzorek, T. (2005), "A Step-By-Step guide to the Black-Litterman Model, Incorporating User-Specified Confidence Levels", *Working paper.*

Grinold, R., & Kroner, K. (2002), "The Equity Risk Premium", *Investment Insights from Barclays Global Investors* 5 (3).

Grinold, R. & Kahn, R. (1995), *Active Portfolio Management*, Chicago, IL: Probus Publications.

Kitchin, J. (1923), "Cycles and Trends in Economic Factors", *Review of Economics.*

Markowitz, H. (1952), "'Portfolio Selection", *Journal of Finance* **7** (1), 77–91.

Markowitz, H. (1959), *Portfolio Selection: Efficient Diversification of Investments*, New Haven: Yale University Press.

Markowitz, H. (1984), "The Two Beta Trap", *Journal of Portfolio Management* **10** (1), 12–20.

Meucci, A. (2010), "The Black-Litterman Approach: Original Model and Extensions", *The Encyclopedia of Quantitative Finance*, Wiley.

Meucci, A. (2005), "Beyond Black-Litterman: views on non-normal markets", Working paper, available at SSRN 848407.

Merton, R. (1969), "Life Time Portfolio Selection Under Uncertainty: The Continuous Time Case", *Review of Economics and Statistics* **51**, 247–257.

Merton, R. (1973), "An Intertemporal Capital Asset Pricing Model", *Econometrica* **41** (5), 867–887.

Mitchell, W. (1954), "*Business Cycles, the Problem and Its Setting"* New York: National Bureau of Economic Research.

Moore, G. H. (1983), *Business Cycles, Inflation and Forecasting* (2nd edition), Cambridge: Ballinger Publishing.

Ross, S. (1976), "The arbitrage theory of capital asset pricing", *Journal of Economic Theory* **13** (3),341–360.

Satchell, S. & Scowcroft, A., "A Demystification of the Black-Litterman Model: Managing Quantitative and Traditional Portfolio Construction", *Journal of Asset Management* 1 (2), 138–150.

Sharpe, W., Gordon A. & Jeffery B. (1999), *Investments*, Upper Saddle River: Prentice Hall.

Sharpe, W. (1966), "Mutual Fund Performance", *Journal of Business* **39** (1), 119–138.

Sharpe, William. 1974. "'Imputing Expected Security Returns From Portfolio Composition"", *Journal of Financial and Quantitative Analysis*. Vol. 9, No. 3: 463–472.

Schumpeter, J. A. (1954), *History of Economic Analysis*, London: George Allen & Unwin.

Theil, H. (1971), *Principles of Econometrics*, Wiley and Sons.

Tobin, J. (1958), "Liquidity preference as behavior towards risk", *The Review of Economic Studies* **25** (2).

Tsay, R. S. (1998), "Outliers, level shifts, and variance changes in time series", *Journal of Forecasting* **7**, 1–20.

Walters, J. (2008), "The Black-Litterman Model in Detail", *Working paper*.

Yamarone, R. (2004), "The trader's guide to key economic indicators ", 2004.

Appendix 1

The NBER Recession based Phases of US Business Cycle (1979–2012)

Period (year/quarter)		The Phase of Business Cycle	Duration (months)	Business Cycle
Beginning	End			
–	1979/q3	Late upswing	N/A, 9 months of data analyzed	Partially completed business cycle with "double-dip recession", 47 months long
1979/q4	1980/q1	Slowdown	6	
1980/q2	1980/q3	Recession	6	
1980/q4	1981/q1	Initial recovery	6	
1981/q2	1981/q3	Slowdown	6	
1981/q4	1982/q2	Recession	15	
1983/q1	1983/q2	Initial recovery	6	Completed business cycle, 99 months long
1983/q3	1985/q4	Early upswing	30	
1986/q1	1989/q3	Late upswing	45	
1989/q4	1990/q3	Slowdown	12	
1990/q4	1991/q1	Recession	6	
1991/q2	1992/q1	Initial recovery	12	Completed business cycle, 126 months long
1992/q2	1996/q1	Early upswing	48	
1996/q2	2000/q2	Late upswing	48	
2000/q3	2001/q1	Slowdown	9	
2001/q2	2001/q4	Recession	9	
2002/q1	2002/q4	Initial recovery	12	Completed business cycle,80 months long
2003/q1	2004/q3	Early upswing	21	
2004/q4	2007/q4	Late upswing	39	
2008 q1	2008 q1	Slowdown	3	
2008 q2	2009 q2	Recession	15	
2009 q3	2010 q1	Initial recovery	9	Partially completed business cycle, 33 months long

Appendix 2

Portfolios Performance Ratios

Risk level	Portfolio Type	Performance Measure			
		Sharpe	**Sortino**	**Drawdown**	**Sterling**
MinRisk	Markowitz	0.91508	0.37984	0.06033	-0.20212
	BL without views	1.61104	0.74600	0.09712	-0.07951
	BL with Fedviews	1.61105	0.74601	0.09712	-0.07951
	BL with NBER views	1.61105	0.74601	0.09711	-0.07951
Min-Mid Risk	Markowitz	1.78132	0.67301	0.06033	-0.16128
	BL without views	1.25870	0.50258	0.17814	0.04281
	BL with Fed views	1.36454	0.68016	0.10687	0.09777
	BL with NBER views	1.37270	0.58016	0.15299	0.08664
Mid Risk	Markowitz	0.78269	0.55071	0.17408	0.07451
	BL without views	0.92402	0.37467	0.29495	0.12835
	BL withFedviews	1.03240	0.54599	0.19073	0.24387
	BL with NBER views	1.37300	0.43724	0.25921	0.19223
Mid-Max Risk	Markowitz	0.64770	0.28283	0.42647	0.16262
	BL without views	0.70015	0.30785	0.40261	0.16212
	BL with Fedviews	0.77926	0.43046	0.24847	0.29179
	BL with NBER views	0.85374	0.37561	0.37197	0.22880
Max-Risk	Markowitz	0.53607	0.25828	0.50351	0.23920
	BL without views	0.48386	0.23571	0.45803	0.25308
	BL withFedviews	0.80986	0.27794	0.43217	0.28791
	BL with NBER views	0.80265	0.36788	0.46054	0.23920
Market Portfolio		0.78950	0.32778	0.37746	0.17837
Simple 60/40		0.94971	0.42914	0.29340	0.17458
Adapted 60/40		1.14333	0.54928	0.18787	0.23243
Equally-weighted		1.10059	0.40897	0.31221	0.01307

TERMINOLOGY

NBER recession indicator is posted quarterly by Business Cycle Dating Committee of US National Bureau for Economic Research (NBER), an official arbiter of recessions for US economy. Committee uses no predefined rule but members' judgment based on macro data, to mark periods of recession with two-quarters lag. Indicator may be equal to 0 or 1, with 1 indicating recession period.

FED spread recession indicator is published monthly by New York FED and varies between 0 and 100, showing probability of US economy falling into recession during next month. This is leading index, calculated from spread between market price for short- and long-term US government debt. Method for calculation, as well as all accompanying materials, is in open access on the site of New York FED.

Black-Litterman and Meucci techniques are "add-ons" to famous Markowitz MVO approach to portfolio optimization. Black-Litterman approach allows to blend portfolio manager forecasts with prior returns distribution, based on assumptions of market returns normality, and uses blended returns as inputs for Markowitz optimisation procedure. Meucci's approach further extends that of Black-Litterman, by allowing returns to be non-normal.

Ensemble learning is class of decision making algorithms, combining forecasts of ensemble of "weak predictors" ensemble (i.e. any other decision making models with low predictive ability) to make one "strong predictor" with higher predictive performance than any of individual predictors, comprising it. Ensemble learning is believed to produce better results when applied to complex, non-stationary processes and high dimensional data.

Corporate sustainability reporting is optional non-financial reporting (often prepared as part of part of mandatory financial reporting), supplying organisation's stakeholders with additional information about social, environmental and governance performance of corporation. By preparing sustainability reports organisation shows to investors and mass media its awareness of bidirectional impacts of organisational activity and various aspects of sustainability, as well as internalizes its commitment to sustainable development and engaging stakeholders.

Real options is a valuation technique, which allows to consider simultaneously several paths or scenarios of development of some basic (for valued object) parameter and the flexibility of object's manager to react in real time to some particular path or scenario being realized. For example, applying real options approach to problem of finding fair rent price for gold mine allows to account for varying gold price and flexibility of mine's management to cease mine operation when gold price is low, and install new equipment when gold price is high. Real options approach have numerous applications in valuing endeavors in R&D, licensing, energy, mining, policymaking, etc. Real options are not traded derivatives; rather it is approach to valuation of objects, the fair value (of benefit from realization) of which could be conceptually tied to price of some underlying asset and depends heavily on decisions taken as reaction to the price change.

Application of Ensemble Learning for Views Generation in Meucci Portfolio Optimization Framework*

Alexander DIDENKO, Ph.D.
Deputy Dean, International Finance Faculty, Financial University, Moscow
alexander.didenko@gmail.com

Svetlana DEMICHEVA
International Finance Faculty, Financial University, Moscow
svetlana86d@rambler.ru

Abstract. Modern Portfolio Theory assumes that decisions are made by individual agents. In reality most investors are involved in group decision-making. In this research we propose to realize group decision-making process by application of Ensemble Learning algorithm, in particular Random Forest. Predicting accurate asset returns is very important in the process of asset allocation. Most models are based on weak predictors. Ensemble Learning algorithms could significantly improve prediction of weak learners by combining them into one model, which will have superiority in performance. We combine technical fundamental and sentiment analysis in order to generate views on different asset classes. Purpose of the research is to build the model for Meucci Portfolio Optimization under views generated by Random Forest Ensemble Learning algorithm. The model was backtested by comparing with results obtained from other portfolio optimization frameworks.

Аннотация. Современная портфельная теория предполагает индивидуальность в принятии решений инвесторами. В реальности большинство инвесторов принимают решения в группах. В данном исследовании предлагается реализовать процесс группового принятия решений применением алгоритма ансамбля обучения (Ensemble Learning), в частности метода “Случайный лес” (“Random Forest”). Точность в предсказании доходностей активов играет большую роль в портфельной оптимизации. Большинство методик основывается на слабых гипотезах. Алгоритмы ансамбля обучения помогают значительно улучшить точность предсказания, объединяя слабые гипотезы в одну модель. Для предсказания доходностей активов мы объединили фундаментальный, технический и сентиментальный анализы. Целью данного исследования является создание модели для портфельной оптимизации по Меуччи, основывающейся на алгоритме ансамбля обучения. Оценка данной модели проведена путем сравнения ее с другими методами портфельной оптимизации на исторических данных.

Key words: Random Forest, Ensemble Learning, Meucci portfolio optimization, combination of fundamental technical and sentiment analysis.

1. INTRODUCTION

Portfolio optimization problem always stays in front of investors. The Markowitz mean-variance optimization theory had big impact on Modern Portfolio Theory. However it is rarely implemented by professional investors. There are some drawbacks which cause the investors to refuse using Markowitz optimization. Firstly the model produces highly concentrated portfolio and generates short position, if there is no constraint for it. The second is that the optimization is made in unintuitive way. Investors always have the views on market realization, which are not considered by the Markowitz model.

Modern Portfolio Theory assumes that decisions are made by individual agents, but practically investors are involved in group decision-making. It was shown that group decisions improve the final outcomes in decision-making process and people before making a final decision always look for other opinions. They are weighting individual opinions and combine them in order to reach more reasonable and accurate decisions. Researches in decision-making theory show superiority of group decision making over individual. Hinsz *et*

* Применение алгоритма «ансамбля обучения» для формирования рыночных оценок при портфельной оптимизации по Меуччи

al. (1997) showed that about 56% of investors are involved in team decision-making.

For realization the group decision-making process in generation the views on selected asset classes is proposed to use Ensemble Learning algorithm. Ensemble learning is type of machine learning approach which combines single classifiers in purpose to construct the model which has superiority in performance. Previous researches in Ensemble Learning, such as Hansen and Salamon (1990), Yuehui Chen *et al*. (2007), Myoung-Jong Kim *et al.* (2005), Se-Hak Chuna and Yoon-Joo Park (2005), Tae-Hwy Lee and Yang Yang (2005), Chih-Fong Tsai *et al.* (2010) have proved that such algorithms improve significantly accuracy and stability of prediction.

Most theoretical and practical analysis is set on weak hypothesis. Ensemble Learning is based on weak learnability. It suggests that basic model should provide results which are slightly better than random guess. Attractiveness of Ensemble Learning algorithms is that it could create strong learning algorithm from weak basic learners.

Purpose of the research is creation of the model for portfolio optimization based on the views which are generated by the Random Forest Ensemble Learning algorithm.

There are different types of ensembles algorithms, but no one of them has superiority in performance over different cases. There are such methods as bagging, boosting, staking, random forest, multi stratagem ensembles. To forecast asset returns in this research it is proposed to use Random Forest Ensemble Learning algorithm.

Random Forest is a variation of bagging method. It was first described in the work of Breiman (2001). The algorithm consists of great number of individual decision trees. Each tree is constructed from a random subset of features.

Investors use technical, fundamental, sentiment analysis for forecasting asset returns in the market. In this research we combine fundamental, technical and sentiment analysis by Random Forest Ensemble Learning algorithm in order to predict returns of different asset class.

Technical analysis is based on the idea that all relevant information about a company is reflected in its price and with the passage of time there is no need to analyse company fundamental information. Fundamental analysis is the group of methods for stock valuation to determine its intrinsic value. Fundamental analysis is an alternative technique to technical analysis in investment decision making. It considers macroeconomic factors and fundamental information of a company to forecast stock returns. Sentiment analysis of financial markets expresses the opinion of investors on the situation in market. This analysis allows forecasting the movements in financial market before it is reflected in stock prices.

The views generated by Random Forest model will be the inputs for Meucci portfolio optimization framework. Meucci Copula Opinion Pooling optimization model extends the Black-Litterman model by allowing investors to set the views in various ways. Views could be either normally or not-normally distributed and could be set in market realization, not only in the parameters which determine the realization of the market. Black and Litterman introduced their model (1992) in order to solve the problems of highly concentrated portfolio and unintuitive way of Markowitz optimization framework.

In order to evaluate results of Meucci portfolio optimization framework under Random Forest views we will backtest the model by comparing it with other portfolio investment frameworks, such as Markowitz portfolio optimization, market portfolio, naive diversification, 60–40 Equity-Bond portfolio.

2. METHODOLOGY

2.1. ASSET VIEWS GENERATION BY ENSEMBLE LEARNING

To use Meucci Copula Opinion Pooling framework for portfolio optimization we first need to generate the views on selected asset classes. For purpose of asset allocating we need to pick up the asset class which will provide the optimal portfolio with required rate of return and will give enough diversification to reduce the specific risk of the assets. For this purpose we include in our analysis such asset classes as US equities, US fixed interest, US real estate and commodities. The proxy for big caps is S&P 500 stock index, for small caps is Russell 2000 Index, for fixed interest are 10-years treasury notes and Moody's Seasoned AAA Corporate Bond Yield, and proxy for oil is oil futures. We use monthly data for the period from January 1990 till May 2013.

There are different methods for producing such views for asset classes, such as fundamental, sentiment, and technical analysis. In this research Random Forest Ensemble Learning algorithm will generate the views on selected asset classes by combining fundamental, sentiment, and technical analysis. In order to achieve better accuracy in Ensemble Learning model we need to comply with diversification principle, it means that there should be big diversity between basic predictors. To achieve this purpose we considered 60 fundamental, sentiment and technical factors for constructing basic classifiers. Following factors were included in our anal-

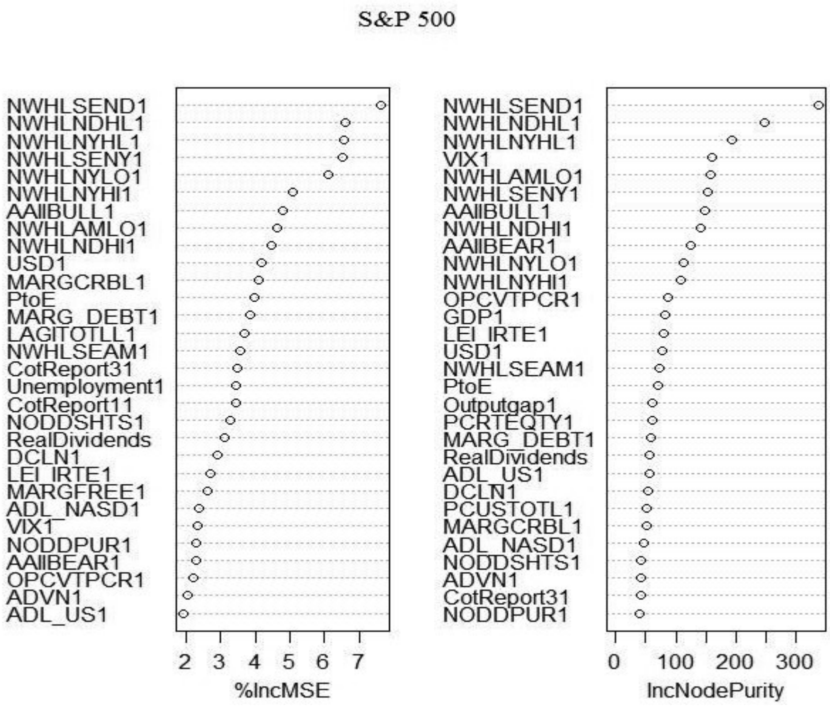


Figure 1. Important variables for S&P 500.

ysis: unemployment, inflation, GDP, output gap, long-term interest rate, U. S. Recession Probabilities, conference board leading and lagging indicators, federal funds rate, volatility index, Michigan Consumer Sentiment Index, commitment of traders, advance –decline indices, sentiment indicators of American Association of Individual Investors, closing arms indices, put-call ratios, new highs- new lows indicators, U. S. Dollar Index, Odd Lot indicators, short interest ratio, NYSE margin, free credits and available cash, S&P 500 EPS, S&P 500 price to earnings ratio, S&P 500 real dividend, S&P 500 real earnings.

The data was processed by using R-programming language.

The dataset which consists of monthly observation of assets returns and monthly values of fundamental, sentiment and technical factors was divided in two samples for training and test purpose. The training sample represents about 70% of dataset and includes the data from January 1990 till December 2005. The test sample represents about 30% of dataset and includes the data from January 2006 till May 2013.

Random Forest constructed the ensemble model by learning from data of training sample. Then the model was applied to the test subset for generating the view on assets returns.

At first Random Forest was built by implying all explanatory variables. Then the variables were evaluated by their ability to explain asset returns. The function "importance" of Random Forest package measures the importance of variables.

The first value (%IncMSE) measures the importance of variable in ability to reduce mean squared error in Random Forest.

The second value (IncNodePurity) shows the importance of variable in ability to decrease of node impurities from splitting on the variable. If the variable is significant in explaining the assets returns then it will have the large value for%IncMSE and IncNodePurity.

Non-significant variables were determined and removed from the dataset for each asset. The significant variables were used for constructing the Ensemble Learning model. Example of important variables for S&P 500 is shown in Figure 1.

The errors in prediction are decreased during increasing the number of trees in Random Forest. It was found out that about 300 trees give minimal error and further rising in number of trees will not improve

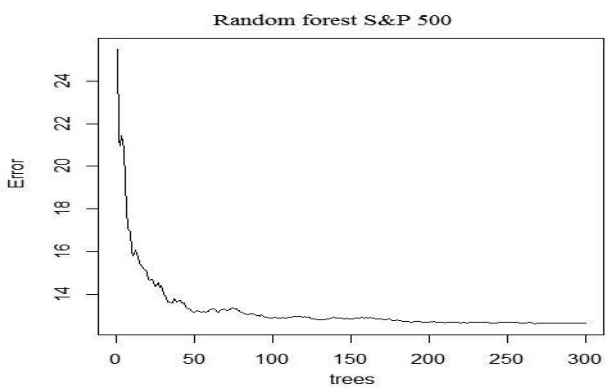


Figure 2. Relation between error and number of trees in Random Forest for S&P500.

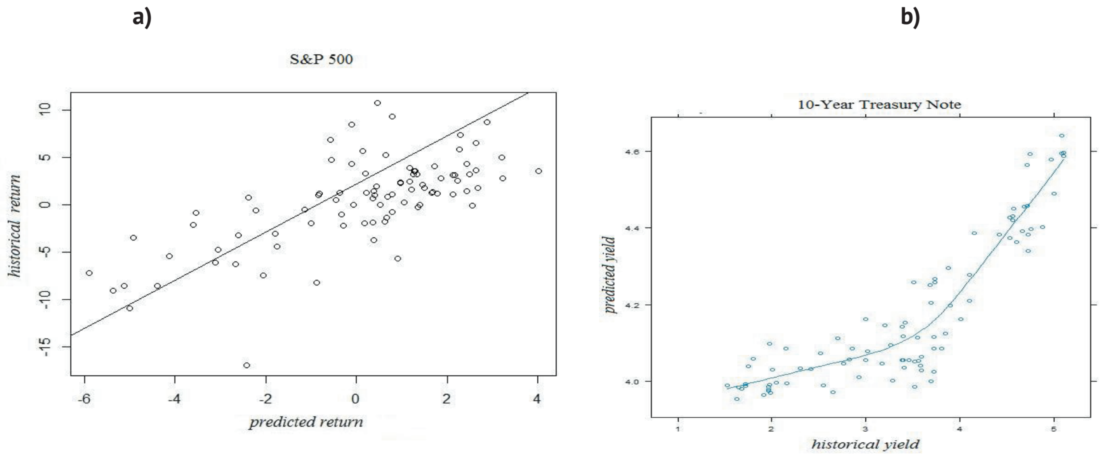


Figure 3. Relationship between historical and predicted values of returns for: a) S&P500 b) 10 Years Treasure Bonds.

the prediction. Example of chart of error reduction in relation to number of trees for S&P 500 is shown in Figure 2.

Expected returns for each asset class were predicted on test subset of data. Predicted and historical values of returns were plotted on returns scatter diagram. Relations between the predicted and actual values of returns are showed by regression line. Examples for S&P500 and 10-years Treasure Bonds are presented in Figure 3.

The charts above demonstrate that there is a relation between the predicted and actual values of asset returns and we can consider them in portfolio optimization by Meucci as inputs variables.

2.2. PORTFOLIO OPTIMIZATION IN MEUCCI COPULA OPINION POOLING FRAMEWORK

Portfolio optimization by Meucci was made using R-programming language. For the realization of Meucci algorithms for portfolio optimization we firstly generate prior multivariate distribution of returns. Following Meucci recommendations we model prior distribution as multivariate t-Student distribution with five degrees of freedom, Black-Litterman equilibrium returns as means and usual matrices of variance and vectors of standard deviation. Equilibrium returns are calculated by the following formula:

$$\mu = \lambda \bullet \sum W_i$$

Where, μ— equilibrium returns

λ — is risk aversion coefficient

$\sum$ — covariance matrix of asset returns during last 60 months

W_i— current capitalization of asset (%)

We calculate risk aversion λ dynamically for each month as:

$$\lambda = \frac{MR - R_f}{(M\sigma)^2}$$

Where, R_f — risk-free rate.

MR — mean return of market portfolio during last 60 months (cap-weighted return of all 7 assets)

$(M\sigma)^2$ — standard deviation of market portfolio historical returns

Capitalization of asset (%) is calculated as:

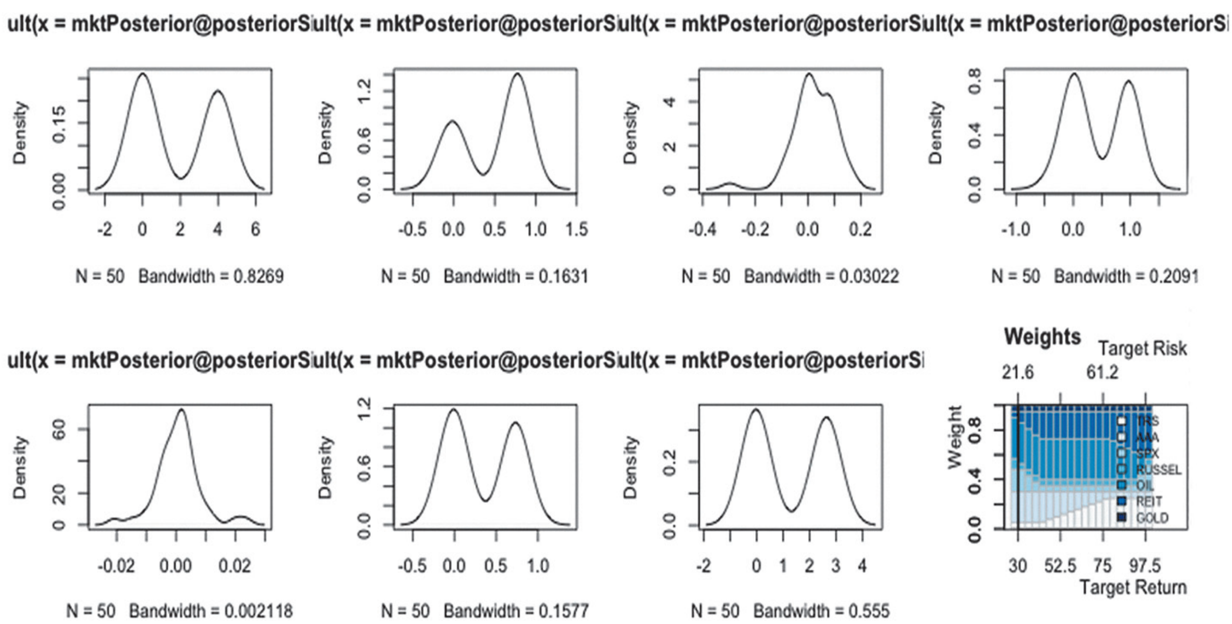
$$W_i = \frac{Cap_i}{\sum Cap_i}$$

Where, Cap_i — Capitalization of the asset class

$\sum Cap_i$ — Sum of the capitalization of all selected asset classes.

Then we introduce views generated by the Random Forest algorithm for each asset class. The views are created as special R-project objects by the COPViews and AddCOPViews functions from BLCOP package. Views on the asset classes are assumed to be normally distributed. Each view is described by mean and standard deviation. Mean equals to return, predicted by Random Forest algorithm, and standard deviation equals to historical standard deviation for assets monthly return.

We then mix views with prior multivariate distribution and generate from this new distribution 500 vectors with 7x1 dimension of possible returns using Monte Carlo Simulation. We calculate means and CVaR risk measures for each of simulated series, and use obtained means and CVaRs as inputs for usual portfolio optimisation. We use portfolioFrontier function from package fPortfolio of R-project statistical software for



10 years Treasury Note; AAA corporate bonds; S&P 500; Russell 2000; Oil; NAREIT; Gold.

Figure 4. Posterior distribution of returns.

constructing the efficiency frontier. Efficiency frontier is thus built basing on CVaR as a coherent risk measure. The example of posterior distribution under applied views of returns is showed in Figure 4. From this figure we can see that presence of bullish views on the asset class, such as Gold or Treasures, increase the weight of the respective asset class in the portfolio. On the contrary, the absence of bullish views for Oil results in relatively small weight of Oil in the portfolio.

We consider six portfolios from efficiency frontier obtained from Meucci optimization for our analysis:

- Tangency Portfolio. This is a portfolio which is located at the tangency point of the efficiency frontier and line drawn from risk-free point;
- Minimum-risk Portfolio;
- Min-mid risk portfolio. It is the portfolio with the average risk between minimum-risk and middle-risk;
- Middle risk portfolio;
- Mid-max risk portfolio. It is the portfolio with the average risk between the middle-risk and maximum-risk of portfolio;
- Maximum risk Portfolio.

For evaluating results of Meucci optimization, we compared the Meucci's portfolios with portfolios obtained from different optimization methods, such as Markowitz, Naive diversification, Market portfolio, 60–40 equity — bonds portfolio.

We consider six portfolios from Markowitz efficiency frontier based on the same principles for risk preference as for Meucci optimization. Market portfolio consists of the asset classes weighted on their market capitalization. 60–40 equity-bond portfolio is a starting point for portfolio optimization for average investor. Equity investments provide growth return opportunities and bonds provide risk-minimization opportunities. Naive diversification suggests to invest in different asset classes with the hope to that diversification will be reached.

Transition maps for optimal portfolios of Meucci optimization under the choosing level of risk are showed in Figure 5. Transition maps for Markowitz optimization are showed in Figure 6.

By comparing the transition maps for Markowitz and Meucci optimization we conclude that Meucci framework provides better diversification across various asset classes. Meucci optimization makes substantial investment in 7 assets for the whole analyzed period. Markowitz portfolio is highly concentrated, and always is allocated between two-three asset classes for considered period.

The box plot of return distribution for portfolios is showed in Figure 7.

Median for each return distribution is showed by vertical line. The boxes show the 50% range of return distribution. Lines limited the 75% range of return distribution. The dots show the outliers of return distribution. We can see that Markowitz maximum risk and max-mid risk portfolios have higher volatility of returns. Portfolios obtained from Meucci optimization have average volatility of returns, which is comparable to the market portfolio, 60–40 Equity-Bonds portfolio and Naive diversification.

Capture Ratio for asset returns is showed in Figure 8. It shows the upside and downside movement

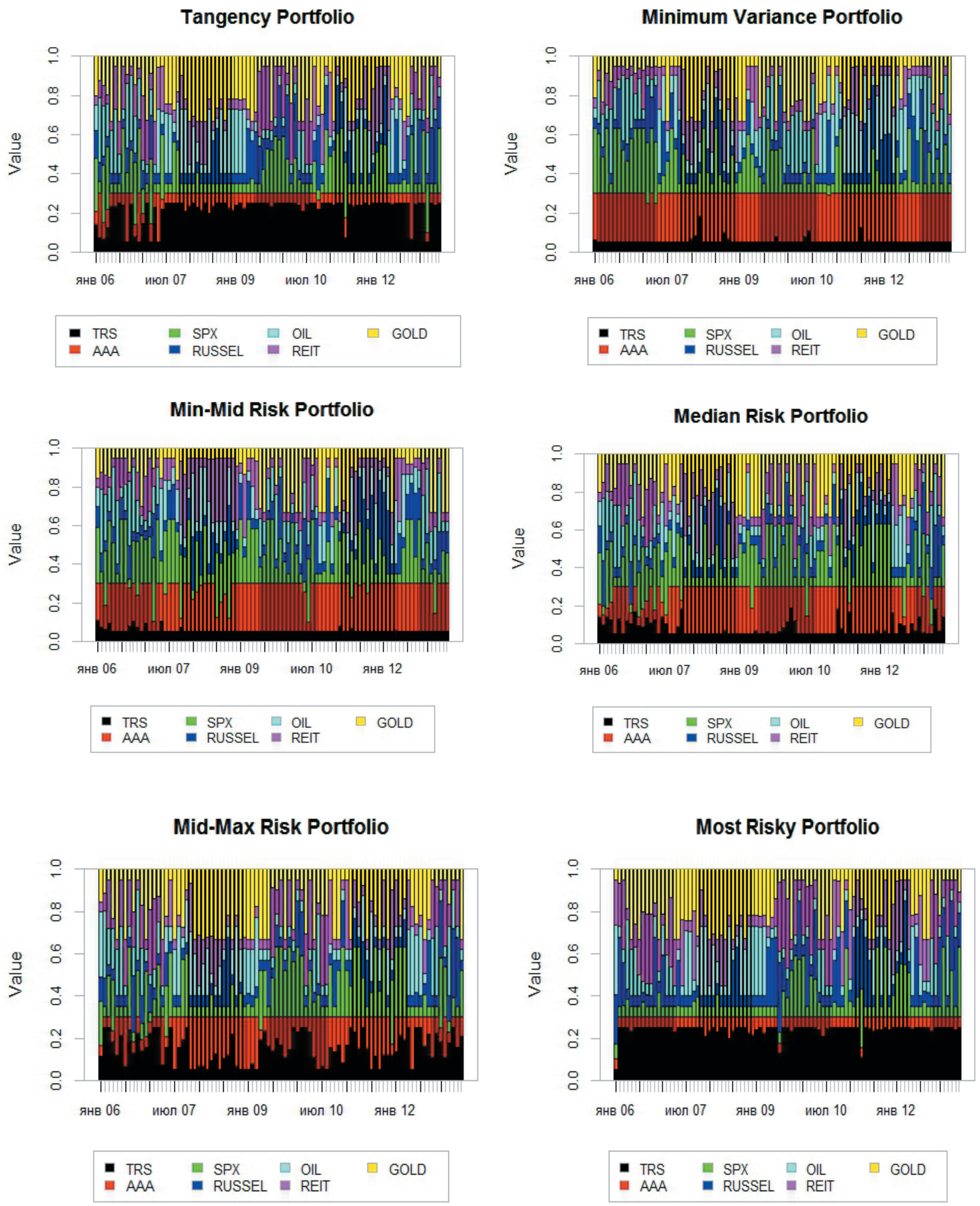


Figure 5. Transition maps of Meucci portfolio optimization.

of portfolio returns in comparison to the market portfolios.

We can see from the chart that when the market moves downside, Gold, Bonds and low-risk Markowitz portfolio go against the market. Equities, REIT, high-risk Markowitz portfolios, all Meucci portfolios move in same direction with market downside movment. When the market moves up Meucci portfolios go against the market same as Equities, REIT and high-risk Markowitz portfolios.

For evaluating the performance of portfolios obtained from different optimization we calculated Sharpe Ratio, Sortino Ratio, and Maximum Drawdown for each portfolio. The results are showed in the Table 1.

The chart for Sharpe Ratio, Sortino Ratio, and Maximum Drawdown measure is shown in Figure 9.

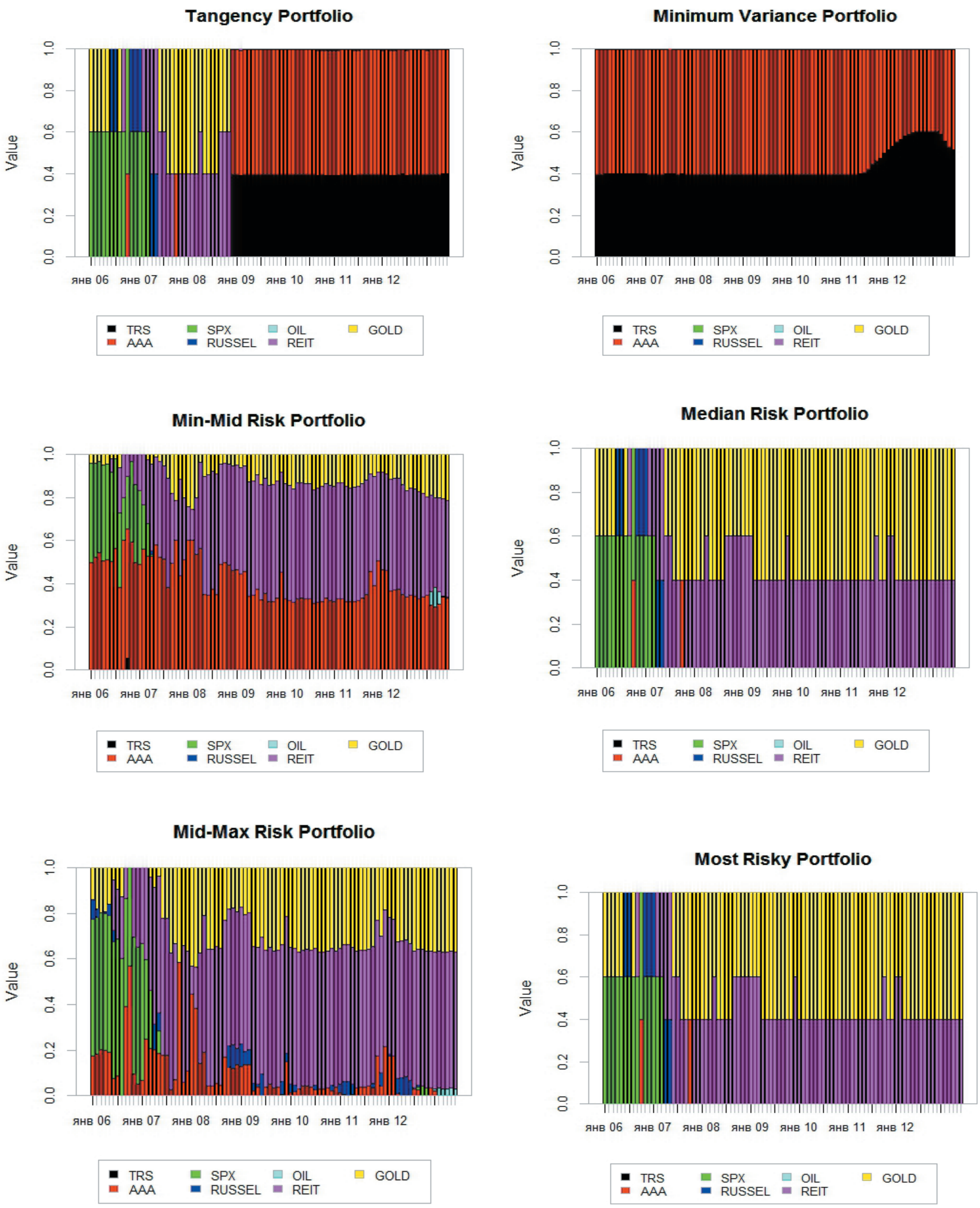


Figure 6. Transition maps of Markowitz portfolio optimization.

Sharpe Ratio is calculated by the following formula:

$$SharpRatio = \frac{R_i - R_f}{\sigma}$$

Where, R_i –return of portfolio
R_f — risk-free rate
σ — Standard deviation

According to Sharpe Ratio Meucci portfolios have good performance. The Sharpe Ratio gives stable results and does not differ significantly across the risk-tolerance. Markowitz's portfolio has good Sharpe Ratio for minimum risk and increasing in risk tolerance leads to decreasing in Sharpe Ratio. For the portfolios with high-risk level Meucci optimization provides better results than Markowitz optimization.

Sortino Ratio based on semi deviation as the risk measure of expected returns. It considers only the

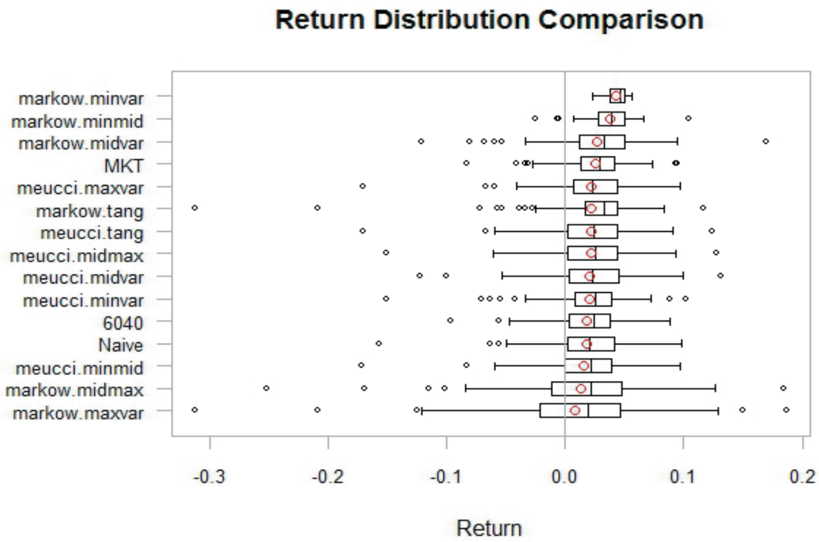


Figure 7. **Box Plot of returns distribution.**

volatility of negative returns. Sortino Ratio is calculated by the following formula:

$$SortinoRatio = \frac{R_i - R_f}{Semideviation}$$

Where, R_i –return of portfolio

R_f — risk-free rate

σ — Standard deviation

Semideviation — Standard deviation of negative returns

Based on analysis of Sortino Ratio, Meucci Portfolios also provides stable results for different risk preferences. There is no big difference in Sortino Ratio for considered Meucci portfolios, while Sortino Ratio for Markowitz portfolio varies significantly under the risk preferences. Meucci optimization provides better results for high risk tolerance, while Markowitz optimization has better results at low-risk tolerance. Sortino Ratio for Markowitz minimum risk portfolio could not be measured because the portfolio consists only of bonds, which provide only positive returns.

Due to the Maximum Drawdown coefficient Meucci portfolios are comparatively better than Markowitz portfolios. All the portfolios of Meucci optimization are stable in Maximum Drawdown and have approximately equal values of drawdown coefficient.

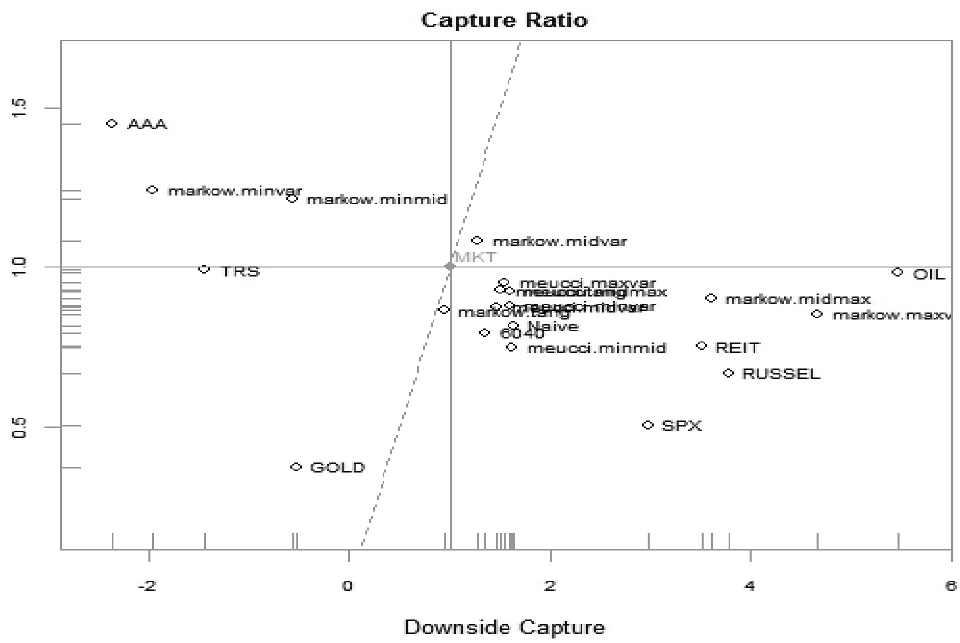


Figure 8. **Capture Ratio of returns**

Table 1. Portfolio ratios.

Portfolio	Sharpe Ratio	Sortino Ratio	Maximum Drawdown
Market Portfolio	3.56	2.13	0.14
60–40 Equity — Bond Portfolio	3.04	1.81	0.13
Naive diversification	1.89	0.85	0.26
Meucci tangent portfolio	2.20	1.00	0.20
Meucci minimum risk	2.11	0.94	0.24
Meucci min- mid risk	1.52	0.67	0.31
Meucci medium risk	2.07	1.01	0.26
Meucci mid-max risk	2.17	1.04	0.26
Meucci maximum risk	2.27	1.03	0.20
Markowitz tangent portfolio	1.49	0.52	0.53
Markowitz minimum risk	19.80	Infinity	0.00
Markowitz min- mid risk	8.42	12.74	0.03
Markowitz medium risk	2.64	1.34	0.23
Markowitz mid-max risk	0.72	0.32	0.51
Markowitz maximum risk	0.30	0.16	0.62
10-year Treasury Notes	13.55	Infinity	0.00
Moody's AAA Corporate Bond	28.44	Infinity	0.00
S&P 500	0.23	0.12	0.53
Russell 2000	0.25	0.14	0.54
Oil Futures	0.19	0.14	0.70
REIT	0.30	0.17	0.68
Gold	0.72	0.36	0.25

3. CONCLUSION

The purpose of the research was to test the model of portfolio optimization under the views generated by Ensemble Learning algorithms. For generating such views Random Forest Ensemble Learning algorithm was used.

We made our analysis for the period from 1990 till 2013 for such asset classes as S&P 500, Russell 2000, 10-years Treasury Notes, AAA Moody's Corporate Bonds. Random Forest model was constructed by learning from data for the period from 1990 to 2006. Testing period of the Random Forest is from 2006 till 2013. The Random Forest was based on sixty fundamental, technical and sentiment factors. The analysis of variables for their ability of explanation of expected returns was made. Non-important variables were eliminated and the Ensemble Learning model generated the expected returns for each asset class taking into account only significant variables. Forecast was made at monthly asset return for each asset class. The views obtained from the Random Forest model became the input variables for generating the posterior distribution of returns. Meucci portfolio optimization was made on posterior distribution of the returns and efficiency frontier is the result of this optimization.

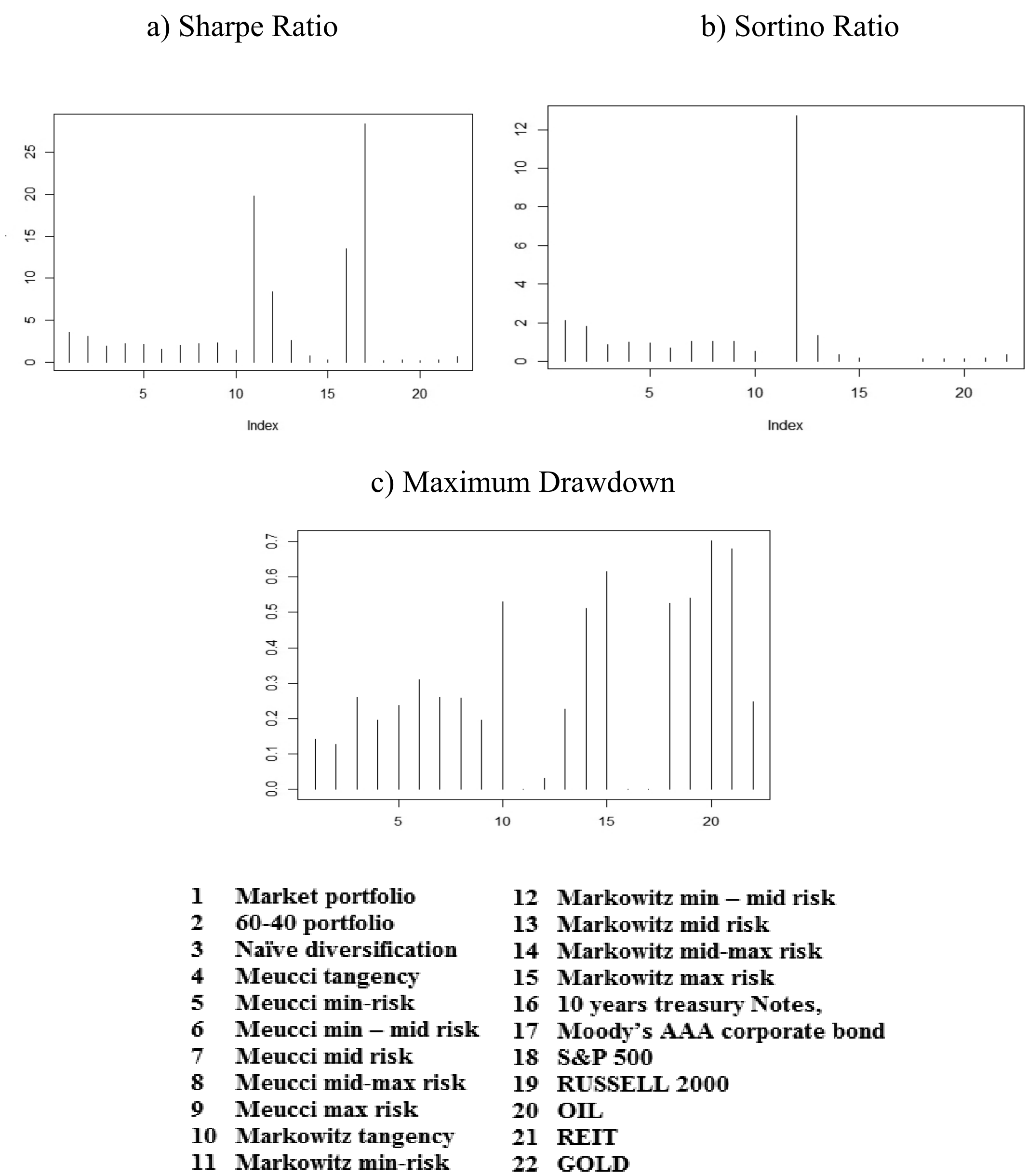


Figure 9. **Portfolio ratios.**

For evaluating the performance of Meucci optimization under the Random Forest views we made comparative analysis for different optimization frameworks, such as Markowitz optimization, Naive diversification, 60–40 Equity-Bonds investment, Market portfolio. For this purpose we analysed six portfolios obtained from Meucci optimization with different risk level: tangency portfolio, low-risk portfolio, min-mid risk portfolio, middle risk portfolio, mid-max risk portfolio and maximum risk portfolio. Markowitz portfolios considered for analysis have the same risk level as Meucci portfolios.

Meucci portfolio optimization framework under the Random Forest views provides highly-diversified portfolio. Markowitz optimization produces highly concentrated portfolio, for all analyzed period it makes allocation between two asset classes.

We evaluated the performance of optimization by analyzing the Sharpe Ratio, Sortino Ratio and Maximum Drawdown coefficient for portfolios.

Both Meucci and Markowitz optimization beats classic "naive" and 60–40 approaches by almost all measures.

For low-risk tolerance portfolio Markowitz optimization provides better results according to Sharpe and Sortino Ratios and Maximum Drawdown measure.

For high-risk tolerance portfolios, on the contrary, Meucci optimization provides better results according to Sharpe Ratio, Sortino Ratio and Maximum Drawdown coefficient. Moreover, mentioned measures of

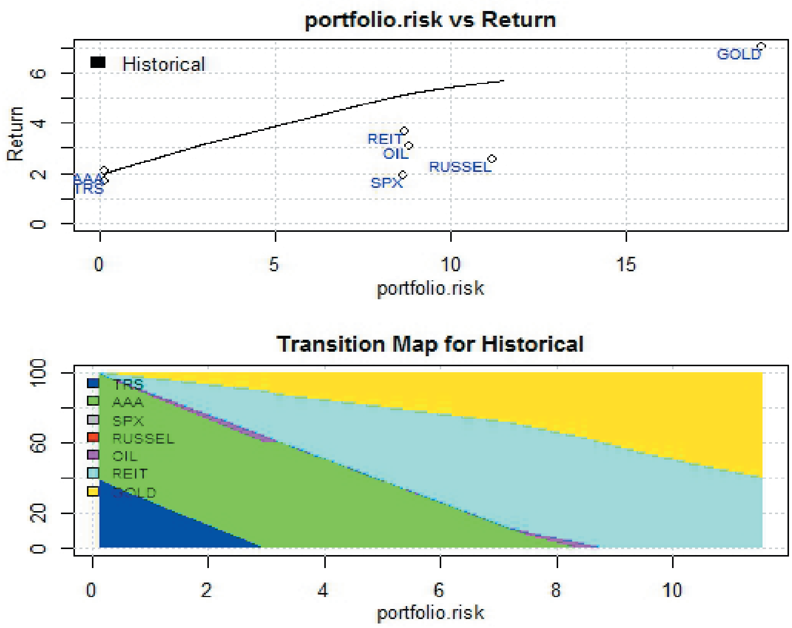


Figure 10. **Efficient frontier of Markowitz optimization.**

Meucci-generated portfolios are not significantly different across risk preferences. That means that while Meucci frontier consists of portfolios with various expected (and realized) risk and return, average payout of each portfolio historical return to historical risk taken (or risk adjusted-return) converges to some market constant, equal for all portfolios. We attribute this to relatively higher level of robustness of Meucci approach as compared to Markowitz approach.

The ratios for Markowitz optimization differ significantly for different levels of risk. Higher absolute performance of Markowitz portfolios could be attributed to the following fact. We make our backtest for the period from 2006 till 2013, and for analyzed period performance of equities was poor. Most Markowitz portfolios avoid investing in equities, which could be explained by usual non-intuitiveness flaws of Markowitz approach (i. e., Markowitz usually invests in two less correlated assets and ignores all others, see Figure 10). Consequently, less exposed to dangerous in 2006–2009 equities, Markowitz portfolios exhibit less drawdowns, less standard deviations and seemingly less risk in general. However this might be just statistical artifact — on longer period well-diversified portfolio would always win.

Meucci portfolio almost always would try to use as wide selection of assets as possible. That makes it more exposed to equity risks of 2007–2009. For better understanding the performance of Meucci optimization future analysis should be applied during economy's healthy period.

The application of Ensemble Learning algorithms for views generation is important topic which needs deeper analysis. Other methods of Ensemble Learning which could be applied for views generation, such as boosting and multi strategy ensembles, stays out of this research. Future research should be done in this sphere for improving the accuracy of predicted returns by Ensemble Learning algorithms.

REFERENCES

Black, F., Litterman, R. (1992), "Global Portfolio Optimization", *Financial Analysts Journal,* 48 (5), 28–43.

Breiman, L. (2001), "Random forests", *Machine Learning*, 45 (1), 5–32.

Chih-Fong Tsaia, Yuah-Chiao Linc, David C. Yenb, Yan-Min Chen (2011), "Predicting stock returns by classifier ensembles", *Applied Soft Computing*, 11, 2452–2459.

Hansen, L.K., Salamon, P. (1990), "Neural network *ensembles", IEEE Transactions on Pattern Analysis and Machine Intelligence*, 12 (10), 993–1001.

Hinsz, V., Tindale, R., Vollrath, D. (1997), "The emerging conceptualization of groups as information processors", *Psychological Bulletin,* 121 (1), 43–64.

Myoung-Jong Kim, Sung-Hwan Min, Ingoo Han (2005), "An evolutionary approach to the combination of multiple classifiers to predict a stock price index", *Expert Systems With Applications — ESWA,* 31 (2), 241–247.

Se-Hak Chuna, Yoon-Joo Park (2005), "Dynamic adaptive ensemble case-based reasoning: application to stock market prediction", *Expert Systems with Applications: An International Journal*, 28 (3), 435–443.

Tae-Hwy Lee, Yang Yang (2005), "Bagging binary and quantile predictors for time series", *Journal of Econometrics,* 135 (1–2), 465–497.

Yuehui Chen, Bo Yang, Ajith Abraham (2007), "Flexible Neural Trees Ensemble for Stock Index Modeling", *Neurocomputing* 70 (4–6), 697–703.

AIMS AND SCOPE

Review of Business and Economics Studies (ROBES) is an editorially independent international academic journal launched by the Financial University under the Government of Russian Federation.

ROBES publishes original research papers on emerging topics of business and economics with focus on advanced international finance, sustainability and emerging markets in Eastern Europe, CIS countries and China. Journal is published in English with Russian abstracts.

Journal's mission is to provide profound scientific perspective on wide range of topical economic and business subjects of Eurasian region. Choice of topics for this quarterly publication is based on discussion between editorial board members formed by renowned academics and practitioners from Russia, USA, Europe and Asia. We use double-blind peer reviewing for paper selection.

Our journal aims to search what is currently most cited and discussed topics in economics and business science, select those topics that might be of interest in current social context for decision-makers in business and government, and connect business and state governance to academia by delivering deep qualitative insights, strongly reasoned with rigorous quantitative methodology. Our scope is emerging scientific research in finance, economics and management for the best interest of business and policymakers.

Key topics of the journal are evolving around current research and citation trends in finance and economics, and range from sustainable development, green finance, energy economics, to corporate governance, organised markets studies, behavioral finance, knowledge economics, corporate social responsibility and social entrepreneurship.

ROBES promotes integrity in academic publications and follows the COPE rules and internationally accepted academic procedures in publishing.

INFORMATION FOR AUTHORS

Review of Business and Economics Studies is especially interested in papers presented by researches who use quantitative methods and modeling techniques with potential impact on business and policy making. Readability and good writing style are important criteria for publication. Content and presentation must be of scholarly caliber.

Manuscripts are received with the understanding that their content is original material not previously submitted for publication elsewhere. We will offer to our authors a rapid publication, high visibility, and user-friendly web-based editorial platform for submission and review.

Inquiries relating to the submission of articles can be sent by electronic mail to robes@fa.ru.

Title and author. Please limit titles to 12 words. Do not use all uppercase letters, or quotation marks for whole title. List names, academic degrees, affiliations, and e-mail address of each author. Include full mailing addresses, phone numbers of author (not to be displayed in publication). The Russian version of title and author information should be provided when possible.

Abstract. The abstracts in English and in Russian (when possible) should be included in the manuscript. If you are unable to prepare a Russian abstract, please inform us in your letter. Abstracts should review the purpose, results, and significance of the paper. Abstracts should have approximately 100 – 200 words. Do not cite references. Do not use undefined acronyms or abbreviations.

Key Words. Submit up to six unique, informative key words or short phrases. Avoid overly general terms and undefined abbreviations or acronyms. Editors reserve the right to replace key words.

Text. Email us a MS Word file that includes the title, authors' names/affiliation/contacts, English abstract, key words, manuscript, and references. Russian versions of title, abstract, and authors information should be provided when possible. Use Times New Roman 12 pt. font in the entire file, including tables, figures, headings, captions, and table notes. Use 1,5 line spacing. Do not use section or page breaks in the running text.

Equations. The author is responsible for ensuring that equations are rendered in vector form. Use Word formula editor.

Tables and Figures. Please do not submit low-resolution images or graphics, which are disproportionately large for the content. In your text please use references to illustrations with numbers. Avoid references such as *see next page* or *see below*. Number all tables and figures (in Arabic) as they are to appear in the text and ensure that all tables are mentioned in the text. Caption should be styled as:

Example: Table 1. Relationship between… Figure 1. Distribution of…

References. The author is responsible for ensuring that all references are cited completely in the text and in the list. Delete the hyperlinks. Examples of references:

Reference in the text (citation):

On the other hand, Jones *et al.* (1988) have reported that …

The List of References:

A complete book:

Jones, P.J. (1980), *Introduction to Algorithms*, London: Methuen.

A chapter in an edited book:

Hamza, K.A. (1988), «Vision Systems», in Jones, P.J., Smith, R. & Watson, E.P. (eds), *Artificial Intelligence Reconsidered* (2nd edition), New York: Wiley, pp. 12-34.

An article in a journal:

Carson, P.R. (1970), «An Approach to Intelligent Planning», *Journal of Applied Artificial Intelligence* **38**(3), 4-11.

Referencing online sources:

Coxhead, P. (2009), «A Referencing Style Guide», http://www.cs.bham.ac.uk/~pxc/refs/refs.html [accessed 17 Oct 2009].