**Is Elegance Useful?**

**Rationality in the Dynamic and Optimal Economic Model**


by Tea Gongadze

under the Direction of

Professor James Hartley


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Mount Holyoke College

South Hadley, MA 01075


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# CHAPTER 1

## INTRODUCTION

In support of the Keynesian theory different mathematical models were created as well and IS-LM model was the most important and successful model in economics for decades. It was dexterous and easy to implement in pedagogy and policy analysis. Its elegance contributed to its widespread usage. It simplified the economy and economic activities while representing results close to reality, at least it used to be believed so. On the other hand, its oversimplified assumptions about the economy lead economists to criticize the IS-LM model as a useful and credible tool for policy analysis because the model's ability to represent reality is crucial when describing different policies.

One of the most important realities that the IS-LM model was lacking of is the pattern of the expectations people have regarding inflation. Adaptive expectations ignored the fact that people use all available information in order to decide how to behave in the future. Separating people's behavior from the economic circumstances would lead you to the wrong description of their expectations and the truth to analyze the actual responses to the economic movements. How could the model without the ability to accurately represent the reality be used for the policy analysis? As a result, model building according to

the Keynesian theory were not popular after few decades when there was obvious need for dynamic and more comprehensive frameworks which at the same time needed to be elegant and easy to work on.

My thesis focuses on the importance of the including rational expectations and more active government in analysis of the economic activities. The purpose of my thesis is to discuss the development of the macroeconomic models in perspective and analyze recent models dominating the economics theory along with discussing a new dynamic model which considers all criticisms of the prior models and incorporates different approaches to the economic fluctuations.

I am representing several crucial modifications in this model, such as including a more flexible form of establishing consumers' inflation expectations, allowing monetary policy to deviate from the Taylor rule in order to capture a more realistic situation, etc. This made the model more dynamic and enabled the framework to better understand the nature of shocks and the monetary policy impacts on the economy.

I will present the historical background for the model building strategies and traditions, which will help me to show the main goals of the models. Looking at the different models over the period of time consolidates different critiques of different models so that I can incorporate them in my analysis of the new Amherst model. The model will be better if it can solve the problems old models had, develop the strengths old models had and, in addition, have a strong competitive advantage which will be reflected in the ability to better describe reality.

# CHAPTER 2

## KEYNES AND KEYNESIAN THOUGHTS

Smith and Ricardo developed the basic line of economic theory. They took people just alike despite their preferences, differences in behavior, culture, race, class, etc. They disregarded the fact that being a person and being different from one another explains the differences in behavior. For economic purposes they created simple theory that explained the responses from the people to the environment in terms of economic changes. Smith believed in free market without any governmental interference, in his opinion, government policies would create inefficient market. He summarized his ideas in his book "Wealth of Nations," where he synthesized theory with simple model of self-driven market equilibrium.

The Keynesian revolution brought an improvement and development of the basic core of economic theory established by Smith and Ricardo. So Keynes and Keynesian economists created better mathematics, better formulation, better data and its processing tools, better statistical methods, more empirical founded theories and more powerful solution methods. The twentieth century was full of developments in statistics, and economists became excited about these improvements in mathematical formulations and about developing the general

equilibrium models. This became the reason for establishing "econometric model-building tradition" (Lucas, 2004, p.22).

Keynes' contribution was to speak for capitalism and emphasize that there is a way to respond to the Depression without turning away from capitalism. He was the person who understood and claimed that government needs to participate and contribute to the stabilization of the economy. He emphasized the importance of spending for economic stability and the "Wealth of Nations." Keynes claimed that there is no need to consider all the details of the economy in order to find the best way to reach a stabilized economy. This became the mainstream of the economic research tradition established by Keynes. "That was Keynes's whole life. He was a political activist from beginning to end. What he was concerned about … was convincing people that there was a way to deal with the depression that was forceful and effective but did not involve scrapping the capitalist system" (Lucas, 2004, p.24).

Keynes made three main assumptions in his General Theory. The first assumption was about the private sector that was represented by simple behavioral rules. In other words, for example, on the real side, consumption and income were connected to each other by "propensity to consume."[1] As for the monetary side, "liquidity preference"[2] determined the demand for cash balance. Nominal prices were exogenous when real activities were analyzed. Secondly, the

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[1] Propensity to consume – refers to the part of your income which you spending on consumption
[2] Liquidity preference – theory that investors prefer to hold more liquid, less risky assets or have premium for riskier investments with long maturity dates.

expectations became an important part of the model in Keynesian theory, although they were exogenous and had no impact on policy analysis. But Keynes did realize that expectations could have a powerful impact on economic activities. Thirdly, in Keynes's opinion, public policy should be adopted by considering the different cases separately.

The General Theory focuses on short run analysis. Keynes suggested that expectations could cause impulses to change the demand for investment and as a result cause business to fluctuate. Since the model was static it could analyze the responses to the shock but it could not incorporate the variables for expectations in order to see the dynamics. For Keynes the long-run was too far away for his model to focus because the purpose of the model was studying short-run decisions from the government (King, 1993).

## 2.1 Creating IS-LM Model

Hicks and Modigliani developed the IS-LM model which foresaw the ideas of Keynesian theory and incorporated a neat economic model that separated the monetary sector from the saving-investment sector. This made policy analysis easier because each response from the government had an impact on only one part of the model (King, 1993).

"The simplest version of the IS-LM model describes the macroeconomy using two relationships involving output and the interest rate" (Romer, 2000, p.150). In general IS-LM model refers to two different markets simultaneously,

one is goods market and another one is money market. The IS curve represents the combinations of the output and interest rates where the goods market is cleared. It is a downward-sloping curve because a higher interest rate reduces the amount of goods demanded at a given level of income. In other words, when the interest rate is higher, then investment becomes lower, as a result the total output decreases as well. Of course, in addition to the investment, consumption reduces as well because the opportunity cost of spending increases and savings become more attractive. Moreover, in an open economy high interest rates bid up the value of the domestic currency causing lower net exports. Owing to all those responses to the high interest rate equilibrium output reduces.

The LM curve in the model refers to the money market. It represents the combination of the interest rate and real output when the money market is at equilibrium. In this version of the IS-LM model the Central Bank followed the money supply rule meaning that the level of money supplied from the Central Bank was considered fixed. As a result the positive relationship between output and the interest rate on the money market was intuitive. If the output increases that means real income increases then the quantity of money demanded increases and that pushes up the cost (interest rate) of the money too so as to make the money demanded equal to the money supplied.

Those two curves, IS and LM curves are put together in the model and their intersection shows the only possible point where both the goods market and the money market are at the equilibrium. Hence it shows output and the interest

rate in a country's economy. Accordingly, fiscal policies have an impact on the IS curve causing an outward shift in case of expansionary policies and an inward shift in case of contractionary policies. And if we have monetary policies the LM curve is affected. The basic version of the IS-LM model has fixed prices and does not incorporate the formulations to understand the changes in price level, thus it does not allow discussing inflation issues because inflation was not a big issue in 1950s (Romer, 2000).

### 2.1.1   IS Variations

Since Keynes there have been several important refinements in terms of theory. Friedman's permanent income theory was one of the most important implications. It emphasized the importance of the income on the consumers' decision. Another change was Modigliani's and Brumberg's life-cycle theory which also studied the characteristics of the decision making process affecting consumption. In addition, there were changes in arguments regarding investment. Neoclassical theorists started implementing expected future production levels and production costs in their models. However, expectations were treated as exogenous. As a result, there were almost no changes in the IS-LM model, although it gave a new platform to economic researchers. These refinements contributed to both pedagogical and empirical economists since the former could develop the theory about the importance of the expectations and the latter could look for the empirical evidence for the theory (King, 1993).

### 2.1.2   *LM Variations*

There were changes in LM part of the model as well. Keynesian theory, that money demand depends on the interest rate, was kept and even more, the importance of expected inflation was emphasized. Money supply was considered to be sensitive to how banks manage their reserves. Hence, the model became static since the banks' decisions about their reserves are exogenous. Friedman suggested that wealth and income had an impact on deciding how much money consumers wanted to have, and in addition to this, inflation was added as a variable to the formulation of money demand. The expectations theory made it necessary to implement "partial adjustment" practices in the model, because each change in the economy will create specific expectation that will lead people to act in certain ways, which of course have their own impact on the economy. This will lead to different expectations and different responses, until the fluctuation is fully adjusted (King, 1993).

## 2.2   **Shortcomings of IS-LM Model**

The IS-LM model was a crucial part of the macroeconomic analysis for decades. Despite its common use for understanding macroeconomic fluctuations, the IS-LM model has had lots of critiques. The critique was that "the model lacks microeconomic foundations, assumes price stickiness, has no role for expectations, and simplifies the economy's complexities to a handful of crude aggregate relationships" (Romer, 2000, p.149).

There have been many new formulations developed in order to create a better economic model. The most important goal has been to have a model with simple enough equations to be used as a "back of the envelope tool." The reality is that there are no simple enough functions able to describe the results which are derived from more sophisticated economic models. The most important shortcoming of using IS-LM model as a simplified version of other complicated economic models is that it has to ignore the importance of the expectations. Hence, the crucial determinants of the aggregate demand will be eliminated without considering expectations. Treating expectation as a static unit in the model jeopardizes the model's trustworthiness to explain business fluctuations and policy impacts (King, 1993).

# CHAPTER 3

## RATIONAL EXPECTATIONS REVOLUTION

### 3.1    The Concept of Rational Expectations

Thomas Sargent indicated that human behavior is shaped according to the rules of "the game in which people are participating" (Sargent, 1980, p.1). It is intuitive if we realize that people take advantage of the environment and their behavior changes along with the changes in the environment. Sargent believed that "models must let behavior change with the rules of the game" (Sargent, 1980, p.1). Economic models represent tools to describe the effects of the economic policies. Most of the time those models try to describe economic agents' behavior. The economic model could be understood as a "decision rules" (Sargent, 1980, p.2) that shows decisions made by people as a function of the rules or information people use to make those decisions. Analyzing the pattern of the past behavior can forecast the future behavior since the rules already exist. But what happens when the rules change? That is, what happens when the government implements new policies?

To begin with the simplest approach to this question, the answer will be that players should change their strategy or actions according to the rules of the game. That means people are not going to behave in the same way as they did in the previous circumstances. Ultimately, they will have a new set of information

and they will make decisions according to the new scenario. In an economic perspective, this is the same as saying that economic models cannot explain the effects of the unprecedented policies unless they consider peoples' ability to change their behavior along with changes in the environment in which they reside (Sargent, 1993).

This brings us to the idea of rational expectations proposed by Muth in the 1960s. In order to understand the future pattern of people's behavior, economists need to understand how people form their expectations to make current decisions. It is intuitive that people would change the way they form their expectations along with changes in the economic system. Muth argued that "one way to ensure…rationality was to insist that expectations of economic actors be consistent with the models used to explain their behavior" (Sheffrin, 1996).

To sum up, rational expectations theory considers that people use all available information in the model to form their expectations and make decisions regarding future behavior and these expectations can change over time if the information changes. Thus, Keynesian and monetarists assumptions regarding policy interventions were wrong, because they used to analyze people as if they act under the new policy environment just as they would act before the policy implementation. This is not going to be accurate assumption because the decisions are not isolated from the circumstances. Thus we need more dynamic models which allow predictions to change and analyze the impacts if the policies under flexible nature of expectations.

After the Philips Curve failure, Robert Lucas suggested a new approach to modeling economic relationships such as forming expectations because most macroeconomic variables depend on the expectations of the future state of the economy to make decisions regarding consumption and investment. People start changing the way they form their expectations about the future once a new policy is implemented. Of course, defenders of the 1960's consensus claimed that Lucas critique was acceptable on a principle level but it has less importance on a practical level (Mankiw, 1988).

In particular, rational expectations theory has recently become an important premise to understand individual and market behavior. The importance of expectations started in the 1950s and 1960s when economists first tried to implement the idea of dynamic models in their studies. Realizing the importance of having dynamic choice in the models pushed the discussion of expectations into the spotlight. Unfortunately for old-timers, this meant that the IS-LM model could not last forever.

Until the rational expectations revolution, it was established that the increase in money stock would increase the demand and as a result nominal and real interest rates could fall. But this approach has changed since introducing the rational expectations. Apparently, because of the influence of expectations on investment, the IS curve might shift so as to raise both the nominal and the real interest rates. "Real rates may rise because investment is sensitive to expected future demand and changes in money may signal sustained increases in demand.

Nominal rates can rise because increases in money signal higher future price levels generating expected inflation and lowering the cost of investing at any given nominal interest rate" (King, 1993, p.69). Rational expectations add different variables to the model that gives you different perspectives on the outcome of the policy changes considering the time period and the persistency of the impact King, 1993).

### 3.2    Rational Expectations and IS-LM Model

Lucas introduced the importance of the rational expectations in the economic model. The idea itself sounded challenging at that time because it was against the IS-LM assumptions. Rational expectations required the short-run and the long-run to be studied jointly in the model. Rational expectations link changes in saving to the changes in the monetary sector because each movement results in new expectations and new decisions. Having a rational expectation in the model changes the formulation of the economic model and adds different variables to the formulas so that the operation of the model changes fundamentally. These changes give the economic model additional power to observe systematic fluctuations in the economy and learn the effect of the implemented policies (King, 1993).

### 3.2.1 Expectations and IS Curve

Rational expectations could explain a theoretical link between consumption and income, in particular, the permanent income hypothesis, which implies three remarkable changes. First is that there is a link between consumption decisions and income, meaning people consider their income when making decisions regarding consumption level. In other words, people decide how much they need and want to consume after analyzing how much predetermined income they expect to receive. It should be mentioned that under the permanent income theory the marginal consumption depends on the nature of the portfolio of different sources of the income. That means, if the increase in your income is temporary then the consumption level is not going to change drastically but if the increase is permanent then the consumption level will increase in the short and long run. Moreover, considering rational expectations, the permanent income model can explain the fluctuations in consumption and income over the business cycles.

> "More generally, rational expectations models of consumption imply that all variable useful for forecasting income and interest rate should enter into the consumption function. Thus, a reduced form IS curve would contain virtually no useful exclusion restrictions; it will depend on everything" (King, 1993, p.76)

Rational Expectations have an impact on investment as well, and empirical evidence shows how dramatic these numbers could be. Studies by Andrew Abel (1982) and Fumio Hayashi (1982) proved that expectation of the future production level and prices have an impact on the aggregate investment.

King (1993) mentioned that there was no single model that could incorporate the dynamic nature of investment because all of them used rapid adjustment theory which meant cost and prices could adjust instantly, but empirical evidence promotes the opposite. In the 1990s there were several new economic models developed trying to implement rational expectations. Using rational expectations analysis creates a more overwhelming model compared to the IS-LM model because multiple consequences arise. One single change from government could have a multiple-sided impact on the economy. Government purchases are supposed to have an impact only on the consumption side of the model, but in fact if you consider rational expectations it has a substantial impact on the investment side, because "higher expected government demand induces a major upward shift in current private investment demand" (King, 1993, p.77) as well.

Persistence of the changes has a crucial role in the rational expectations analysis. "If the changes in the money stock are persistent, then they lead to the persistent changes in aggregate demand." (King, 1993, p.77) Investment can change at any given interest rate if the persistence of the output demand changes and if the persistence is long enough it might cause additional increase in expected inflation (King, 1993).

### 3.2.2   Expectations and LM Curve

According to King, there is no empirical evidence for the substantial impact of expectations on LM curve. "This is critical area for future research. Put

in slightly different terms, we need to know how to separate observed money demand residuals into (i) exogenous shifts in determinants of transactions demand patterns and transactions costs; and (ii) responses to omitted exceptional elements"( King, 1993, p.78).

# CHAPTER 4

## THE NEED OF THE NEW VARIATIONS WITH NEW ADVANTAGES

"The Hicks-Hansen [IS-LM] diagram has elegant simplicity that appeals to many" (Ackley, 1968. p. 372). It also has many disadvantages, such as not including all crucial information for economic analysis. There are ideas and information that are hidden in the IS-LM model and you need additional diagrams or verbal description for those to make a clearer picture.

Of course, there are some more sophisticated models that offer better descriptions of the economic activities but they are difficult to explain and hard to understand. Nelson gives a description of a model that follows the IS-LM approach. The model should have two equations, one that will describe the real variables in terms of consumption and spending so that the total output will be presented. The second equation should describe real money demand on the market. The modifications of the IS-LM model should reformulate the model differently and make optimized spending decisions depend on expectations (Nelson, 2004).

David Romer (2000) suggests several changes as well. The first thing is that the Central Bank follows an interest rate rule rather than targeting the money supply. This assumption is more realistic and better describes the Central Bank's activities. In other words, the Central Bank controls a real interest rate as a

function of other economic variables and makes sure that the real interest rate behaves in a certain way. Secondly, Romer suggests that economic analysis is better conducted in the simplest version of the model. In other words, new models should be simple enough to understand and make changes so as to analyze policy impacts. And finally, the dynamics in the model should be straightforward and reasonable, that means it should allow the user to make changes and, in addition, observe the impact of those changes with consideration of expectations. "One can fully incorporate endogenous changes in expected inflation into the analysis of the aggregate demand side of the model" (Romer, 2000, p.164).

When new variables or theories are added to the economic model they need to be discussed in terms of changes in pedagogical, empirical and econometrical purposes of the model. The goal of pedagogical economics is to create economic theories based on econometrical studies in order to develop students' intuition about policy impacts in the economy.

Robert King (1993) challenged the idea that Keynes's IS-LM model is the best way to understand economic activities and policy effects on business cycles because this model omits one of the quantitatively important factor, rational expectations.

King (1993) suggested that economists were at the point to start working on small dynamic models which would be easy to understand and intuitive to analyze policy impacts so that it could replace the IS-LM model in pedagogy. On the other hand, medium-sized models need to be created in cooperation between

economists and policy makers so as they could use them as laboratory tools for analyzing policy issues and business cycles.

## 4.1    New Developments

Understanding the importance of rational expectations can be considered as one of the most important developments in macroeconomic studies. The first category of researchers according to Mankiw tries to implement expectations in macroeconomic models. They try to develop the studies of forming the expectations and try to understand how to include those expectation decisions in the models so as to have a "more elegant and, ultimately … more useful" model (Mankiw, 1988).

The second category of researchers tries to explain macroeconomic activities within the equilibrium models. Equilibrium models imply that prices and wages adjust in order to equate supply and demand. But in order to explain business fluctuations non-market-clearing models are necessary. That`s how the third category started to come to existence. The third category studies macroeconomic activities within the context of disequilibrium models. The Latter is closer to the IS-LM model because it does not assume the economy to be always at the zero potential output (Mankiw, 1988).

Despite different views of different schools they share similarities as well. Such as the idea that macroeconomic behavior can be described with a simple general equilibrium model and in addition, macroeconomics should be grounded

on microeconomic principles. However, differences arise even here, at first, real business cycles and new classical economists base their theories on simple models that incorporate "perfect information, perfect competition, and the absence of transaction costs, and the presence of complete markets" (Greenwald, Stiglitz, 1993, p 24). They use a representative agent model. They don`t use risk markets to study the economic agents behavior. Usually their assumptions allow markets to be Pareto efficient. In fact, those imperfections are main source of economic problems and when you are studying those economic fluctuations omitting the "imperfections" is the same as "leaving Hamlet out of the play" (Greenwald, Stiglitz, 1993, p 24).

New Keynesians have two different approaches which splits them fundamentally. One believes in nominal price rigidity. Considering this assumption, we can argue, in contrast, that price flexibility would allow the economy to adjust quickly so as to maintain full employment and efficiency. Under this theory, the classical dichotomy[3] breaks down since it allows monetary policy to have an impact other than on the price level.

The second strand of new Keynesians claim that flexibility might even cause exacerbated economic downturn. In other words, perfect wage and price flexibility does not imply that output and unemployment are protected from being highly volatile. Under this theory, monetary policy has real effects even when wages and prices are flexible (Greenwald, Stiglitz, 1993).

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[3] Classical dichotomy – the idea that real and nominal variables should be analyzed separately.

Since Hicks created the IS-LM model based on Keynes's General Theory, there have been many variations and additions to the IS-LM model. Of course, no model is universal and IS-LM is not either. It might be suitable for describing certain issues in the economy whereas it can become a complete failure for others. And changes happen all the time in the economy, theories and approaches to economic activities.

Another important change that occurred, in addition to rational expectation revolution, was economists' attitude towards the Central Banks' target. The original IS-LM assumes that the Central Banks pay attention to the money supply, when nowadays economic theory suggests that the Central Banks switched their attention away from the monetary aggregates. (Romer, 2000)

# CHAPTER 5

## THE IS-LM MODEL PERSISTS

The IS-LM model was introduced to public in the 1960s and since then different economists (classical, Keynesians, new classical and new Keynesians) from different periods of time have had different approaches to this model. Even the use of the IS-LM model has evolved over the time. And today the importance of the IS-LM model in empirical economics has diminished, although the pedagogy still keeps IS-LM as one of the most important tools for explaining short-run fluctuations and policy impacts.

David Colander (2004) wrote about the persistence of the IS-LM model and the development of the way it has been used since the 1960s. Colander argues that IS-LM analysis is "a creature of pedagogy" (Colander, 2004, p.305). Pedagogy is exactly where IS-LM is still alive and commonly used. Mainly the IS-LM framework is intuitive and easy to explain to students who do not have a sophisticated math background and are interested in macroeconomic policy effects.

Recently the IS-LM model's applicability has significantly reduced; it was one of the most important frameworks for both theoretical and empirical

economics in the 1960s though. However, you can find IS-LM in macroeconomic theory books. Graduate courses rarely mention it.

While IS-LM model is not used in empirical studies any more, there are some attempts to translate new economic concepts in an IS-LM framework so that it is easier for policy-oriented economists to discuss their ideas about policy impacts.

Since 1960 the economic situation has changed and so did the policy debates, as a result the spotlight moved away from IS-LM model. In 1960s and 1970s IS-LM model was "the end of the line" – it combined the Keynesian and classical models so that it became the fundamental framework for both policy debates and theoretical work in economics. Today everything has changed; the discussion of the multimarket goods and money market equilibrium gets far less emphasis and owing to this, the IS-LM model became pure framework for policy discussions.

In the 1960s the IS-LM model was a stepping-stone to higher economic studies, when today it is used only in pedagogy without having the impression that the IS-LM model represents a simple example of the much larger economic models. The reason is that the IS-LM model lost the credibility of being the accurate way of describing economic movements on the macro level.

"The central theoretical debates have moved away from the IS-LM model, but IS-LM's pedagogical role as an organizing structure for nonspecialists to think about macro policy has remained" (Colander, 2004, p.310).

The persistence of the IS-LM model is connected to the goals of the intermediate macroeconomics course or graduate-level public policy courses. As for the intermediate macroeconomics course, its main purpose has changed over time. It used to be the course that was supposed to prepare economics majors for graduate level studies; therefore they used the IS-LM model because it was considered as a fundamental model in economic studies to prepare students for high level economic models that would be similar but more sophisticated than the IS-LM model. Nowadays this has changed, intermediate macro course is not designed to prepare students for graduate studies and there are several reasons for this. First of all, few majors continue their studies in graduate schools and secondly, there are students who are not economics majors but still take the intermediate macroeconomics course (Colander, 2004).

So, the student body has changed and the course is differently structured because now it should focus on the needs of students who are interested in macroeconomic policy and do not intend to go to graduate schools. Their main interest is to learn more about macroeconomic activities, monetary and fiscal policies and the problems of long and short run policies. For these purposes they do not need highly sophisticated models, they do not care about the accuracy and limitations of the model as long as it shows the results that are close to reality. Owing to their needs IS-LM model is perfect, it is elegant, simple and shows the impacts of different government policies (Colander, 2004).

In addition to this, older generations of professors are more comfortable with teaching the IS-LM model rather than incorporating a new one. On the other hand, there is a push to eliminate the IS-LM model in intermediate macroeconomics books from the recent graduates who have started teaching recently. This is understandable because they prefer to teach whatever they learned. So they argue to have simpler versions of the economic models which are taught to graduate students. This is where a problem arises; there are no simpler versions of the economic models that are offered at graduate schools and the models itself are mathematically too sophisticated to be offered at intermediate level (Colander, 2004).

On the contrary this does not mean that new text books do not include modern discussions in economics. They indeed include new ideas about credibility, time inconsistency, rational expectations, real business cycles, and inflation targeting but all these aspects remain on verbal representation level. The IS-LM model has been neither replaced to reflect those ideas nor taken away all together. "Economists are not trained in verbal analysis," (Colander, 2004, p.312) as a result the model is crucial in course work. Moreover, using a simpler model makes exam structuring easier because questions about geometric models are either right or wrong, thus it is easier to grade.

The reason why the IS-LM model will keep dominant place in pedagogy is that there is no other pedagogical model created and IS-LM is simple and elegant enough; it does not have sophisticated math level, it gives students a chance to get

right or wrong answer. The advantage of the IS-LM model is that it looks similar to a supply and demand model, thus it feels familiar to the students. Moreover, it is a nice simple representation of complicated monetary or fiscal policies. Finally, the IS-LM model has elegance that enables students to talk about policy impacts without fully understanding the connection between the goods and money market.

On the other hand, the model representation has changed because of new professors' integration in pedagogy. They have not learned the IS-LM model in graduate schools so they do not emphasize the true meanings and foundations of the curves in the model. They do not explain the technical side of the model to the students; it is understood just as "a model that shows the effects of monetary and fiscal policy on interest rates and real output" (Colander, 2004, p.313). New generation of professors emphasize the model and discussions about policy issues are based on the IS-LM model whereas old generation of professors preferred to discuss components of the model and the ideas behind formulations. "Because the modern course focuses heavily on policy, ironically, that means that the IS-LM model is given more, not less, emphasis in Mankiw" (Colander, 2004, p.319).

"What has persisted is the particular graphic technique of looking at multimarket equilibrium in equilibrium space and using the curves in that model to discuss monetary and fiscal policy" (Colander, 2004, p.319). The competitive advantage of the IS-LM model is that it is elegant and easy to understand. It has upward- and downward-sloping curves that allow students to discuss policy

effects without mathematical complications. It is simplified economic model derived from the sophisticated economic thoughts and adjusted to the already well-known supply and demand curves. "…its elegance allows a clouding over of the theoretical issues and underpinnings of the model" (Colander, 2004, p.319).

# CHAPTER 6

## RECENT MODEL BASED ON THE IS-LM MODEL

### 6.1 A Dynamic Model of Aggregate Demand and Aggregate Supply by N. Gregory Mankiw

Gregory Mankiw described two different economic models in his text book for macroeconomics. One is a simple demand and supply model that describes the market for goods and services and the second, called a dynamic model of aggregate demand and supply (DAD-DAS). For the purposes of my thesis, I am focusing on the latter since it has a dynamic and more complicated nature than the former one. Claiming to have more economic factors under control, this model is supposed to better explain business cycles. DAD-DAS model has an ability to control for exogenous variables that are part of the real economic environment and test their impact on the output and inflation.

It should be mentioned why we can correlate the output and inflation. For this, one needs to remember the Phillips's Curve that describes the tradeoff between the unemployment and inflation. So again, Phillips's Curve shows that higher unemployment leads to lower inflation. That means that policymakers' wish to have low inflation along with lower unemployment is unattainable. One might ask where the output is in this law, but one should remember that exactly output determines the level of unemployment according to Okun's law. The

higher the output is the higher the demand for labor market is since employers need more people to produce their products. On the other hand, higher output means that people feel richer and their demand for goods and services increases which increases prices as well, consequently high prices means high inflation.

This model shows the response of output and inflation to exogenous changes in economy. In addition, considering the realistic features of the monetary policy, the DAD-DAS model contains the scenario closest to real world practices when the Central Bank's response mainly concentrates on targeting the real interest rate rather than directly controlling the amount of money supply.

Ultimately, the goal of the DAD-DAS model is to discover the correlation between the inflation and output that will lead us to the point of short and long term equilibriums and from there we can talk about the economic fluctuations and business cycles.

## 6.2     Exploring the DAD-DAS Model

The DAD-DAS model includes five equations. These five equations create a big picture of how five endogenous variables are linked to each other.

| | |
|---|---|
| $Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \epsilon_t$ | The Demand for Goods and Services |
| $r_t = i_t - E_t\,\pi_{t+1}$ | The Fisher Equation |
| $\pi_t = E_{t-1}\,\pi_t + \varphi(Y_t - \bar{Y}_t) + v_t$ | The Philips Curve |
| $E_t\,\pi_{t+1} = \pi_t$ | Adaptive Expectations |
| $i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi^*_t) + \theta_Y(Y_t - \bar{Y}_t)$ | The Monetary-Policy Rule |

*6.2.1   The Demand for Goods and Services*

$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \epsilon_t$

In this equation $Y_t$ is the total output of goods and services, $\bar{Y}_t$ is the economy's natural level of output, $r_t$ is the real interest rate, $\epsilon_t$ is a random demand shock, $\alpha$ and $\rho$ are parameters greater than zero. The parameter $\rho$ (2%) is the natural rate of interest that is a rate that is needed in the absence of any kind of shock so that the natural level of output will equal the demand of goods and services. This equation is similar to IS equation explaining the demand for goods and services.

A key feature of this equation is the negative relationship between the real interest rate and output. In other words, this equation shows that when the interest rate increases, investment and consumption decrease. Consequently, demand for goods and services lowers and output is less. The parameter $\alpha$ shows the sensitivity of the demand when the real interest rate changes. We need to keep in

mind that the long-run growth should be reflected on $\bar{Y}_t$. If we look at our equation the more the natural level of output is the richer people are and therefore they spend more.

Throughout history we have observed some random shocks on the economy that cannot be explained, for this, the model includes a variable that captures a variety of exogenous influences on the demand. From Keynes we have heard about the "animal spirits," the idea that some portion of decisions might be driven by irrational pessimism or optimism which apparently has an impact on the output. This reaction is described by having a "random variable" in the equation which is zero on average but deviates in case of some changes in sentiment. In addition, the "random variable" might capture random changes in the fiscal policy such as government spending or tax policies that affect the demand for goods and services.

### 6.2.2    The Fisher Equation

$r_t = i_t - E_t \, \pi_{t+1}$

The Fisher Equation defines the real interest ($r_t$) rate as the nominal interest rate ($i_t$) minus the expected rate of future inflation ($E_t \, \pi_{t+1}$). The Fisher Equation describes the correlation between the real interest rate and the nominal interest rate. In this equation notations have an important role. This equation shows that we need the current real and nominal interest rates that depend on the current expectation of the future inflation.

### 6.2.3 The Philips Curve

$$\pi_t = E_{t-1}\, \pi_t + \varphi\, (Y_t - \bar{Y}_t) + v_t$$

The Philips Curve represents the relationship between the rate of inflation and GDP gap. There are three factors that have effect on the current inflation. At first, there exist last period's expectations $(E_{t-1}\pi_t)$ regarding this year's inflation. This factor plays substantial role in the model because many firms set their prices in advance according the inflation they expect. Secondly, we can observe actual deviation in output $(Y_t - \bar{Y}_t)$ and measure the constant $\varphi$ $(>0)$ which tells us how much inflation responds when output fluctuates. Thirdly, we have external impact $(v_t)$ on the inflation that is random supply shock that averages to zero but can be positive or negative.

### 6.2.4 Adaptive Expectations

$$E_t\, \pi_{t+1} = \pi_t$$

Since we mentioned the concept of expected inflation we need to determine how economic expectations are formed. In order to make our model simple and make it easy to observe different shocks without having any important insights lost, we assume that people observe recent inflation conditions and accordingly make their predictions about future inflation. Adaptive expectations assume, people simply look at the current inflation rate and expect the same for the next period.

*6.2.5  The Monetary-Policy Rule*

$$i_t = \pi_t + \rho + \theta_\pi (\pi_t - \pi_t^*) + \theta_Y (Y_t - \bar{Y}_t)$$

In the DAD-DAS model the money supply is not the policy instrument. Here we assume that the Central Bank sets a target for nominal interest rate and then it adjusts the money supply so that the interest rate hits the target.

In this equation it is clear that the Central Bank sets the nominal interest rate ($i_t$) based on output and inflation where $\pi_t^*$ is the target inflation rate. In the equation we have two parameters $\theta_\pi$ and $\theta_Y$. They are chosen by the monetary policy makers according to their wish of how much the interest rate should change when inflation and output fluctuate.

In addition, we know that the nominal interest rate is the sum of the real interest rate and the expected inflation which is the current inflation since we assume adaptive expectations. Consequently, we can see how the Central Bank's influence in fact works through the real interest rate. From the equation we can show that when output is at its natural level ($Y_t = \bar{Y}_t$), inflation is at its target ($\pi_t = \pi_t^*$) last two terms are zero. And so the real interest rate equals the natural rate of interest. We need to capture that the interest rate changes along with inflation and output in the same direction.

In this case, we assume that the Central Bank can adjust a real interest rate based on inflation and output. In fact, the Central Bank does not change the real interest rate directly itself. The Central Bank can set a target inflation rate, adjust

the responsiveness of the interest rate to the inflation and output in the monetary-policy and, in the end, set the money supply.

As for the Central Bank choosing the parameters we use the Taylor Rule that assumes that natural rate of interest and target inflation rate are 2 percent and the parameters of the responsiveness of the nominal interest rate to output and inflation are 0.5 percent.

# CHAPTER 7

## THE NEW AMHERST MODEL

*Extending the textbook dynamic AD-AS framework with flexible inflation expectations, optimal policy response to demand changes, and the zero-bound on the nominal interest rate*
    *By Sami Alpanda, Adam Honig, Geoffrey Woglom*

Alpanda, Honig and Woglom have offered a new version of the DAD-DAS. This model was created only in July 2011; since it is recently issued there is not much research on it and we only have the authors' ideas and claims about this model.

According to the authors their framework will better explain business cycle fluctuations and the effects of the monetary policy because they adjusted Mankiw's DAD-DAS model and made changes in the model equations. In addition, they created an Excel sheet that enables users to see and analyze effects of different shocks to the economy using DAD-DAS diagrams.

## 7.1    Exploring the Model

The model is based on Mankiw's DAD-DAS model. The authors made several crucial modifications that made enabled the framework to better

understand the nature of shocks and the monetary policy impacts on the economy. The first important change was including a more flexible form of establishing consumers' inflation expectations. Secondly, they added a third shock to the model, which is a shock to the risk-premium. Thirdly, they allowed monetary policy to deviate from the Taylor rule in order to capture a more realistic situation when the monetary policy tries to keep the Taylor rule but due to external impulses they can`t reach the Taylor rule. At last, the authors impose a zero bound (nominal interest rate cannot go below zero) on the nominal interest rate and they modeled the persistence of shocks considering permanent and temporary shocks to demand.

The model includes five main equations and three additional ones which explain the components in the main equations.

| | |
|---|---|
| $Y_t^{gap} = -\alpha(r_t - \rho) + \mathcal{E}_t^{demand}$ | The Demand for Goods and Services |
| $r_t = i_t - E_t \pi_{t+1} + \mathcal{E}_t^{risk}$ | Nominal and Real Interest Rates |
| $\pi_t = E_{t-1} \pi_t + \varphi Y_t^{gap} + \mathcal{E}_t^{cost}$ | The New-Keynesian Philips Curve |
| $E_t \pi_{t+1} = \gamma \pi_t + (1-\gamma) \pi_{t+1}^{target}$ | Rational Expectations |
| $i_t = \max \{0, \rho + E_t \pi_{t+1} + \theta_\pi(\pi_t - \pi_t^{target}) + \theta_Y Y_t^{gap} + \Delta_t^{monet}$ | The Monetary-Policy Rule with zero bound |
| | |
| $\Delta_t^{monet} = (1-\delta)\Delta_{t-1}^{monet} + \delta(1/\alpha * \mathcal{E}_t^{demand} - \mathcal{E}_t^{risk})$ | The deviation from the Taylor Rule |
| $u_t - u^n = -\beta Y_t^{gap}$ | Okun's Law |
| $\mathcal{E}_t^i = \omega_i \mathcal{E}_{t-1}^i + \eta_t^i$ | Persistence of Shocks |

### 7.1.1 The Demand for Goods and Services

$$Y_t^{gap} = - \alpha (r_t - \rho) + \mathcal{E}_t^{demand}$$

The demand side of the model is identical to Mankiw's DAD-DAS model since it is based on the IS equation. In this equation $Y_t^{gap}$ represents the percent-difference between actual output and the natural rate of output. $\alpha$ is an elasticity parameter that shows how sensitive the output is to the changes in the real interest rate. In Mankiw's model $\alpha$ is equal to 1 as a benchmark, and this model keeps it at 1. $r_t$ is a real interest rate in the period of time. $\rho$ is the natural real interest rate that is the real interest rate in the long run. Mankiw's model sets $\rho$ equal to 2%, and this model keeps it at 2%. $\mathcal{E}_t^{demand}$ is a demand shock where positive value generates a higher output gap, which means the upward push on the output of the period caused by circumstances other than changes in the interest rate.

This equation as well as in Mankiw's model captures the negative relationship between the real interest rate and the output. In other words, when the interest rate exceeds the natural real interest rate, consumption and investment demand are constrained which makes the output gap negative.

### 7.1.2 Nominal and Real Interest Rates

$$r_t = i_t - E_t \pi_{t+1} + \mathcal{E}_t^{risk}$$

In this equation we see the first difference from Mankiw's model since the real interest rate ($r_t$) is defined as the difference between the nominal interest rate ($i_t$) and expected inflation($E_t \pi_{t+1}$), which is the Fisher Equation, plus a risk-

premium shock ($\varepsilon_t^{risk}$). A risk-premium shock represents a wedge between the policy rate set by the Central Bank and the cost-of-capital and borrowing costs incurred by final demanders.

### 7.1.3 The New-Keynesian Philips Curve

$$\pi_t = E_{t-1} \pi_t + \varphi\, Y_t^{gap} + \varepsilon_t^{cost}$$

The short-run supply is represented by the Philips Curve in this model as well. As mentioned in Mankiw's model there is an inverse relationship between inflation rate and unemployment. In other words, there will be high inflation if the output gap is high, that means we have an increased output level that causes low unemployment. In addition to output, current inflation rate depends on the past expectations regarding current inflation. A supply shock ($\varepsilon_t^{cost}$) that captures changes in current inflation due to unexpected changes in costs has an impact on inflation rate as well. And the parameter $\varphi$ shows how sensitive inflation rate could be to the changes in the output gap.

### 7.1.4 Rational Expectations

$$E_t\, \pi_{t+1} = \gamma\pi_t + (1-\gamma)\, \pi_{t+1}^{target}$$

The most important difference between Mankiw's model and this model is captured in the formation of consumers' expectations. The authors changed the expectations forming equation to allow for the possibility of rational expectations.

In this equation $\gamma$ is a parameter that determines how much effect the current inflation has on the expectations about the future inflation. If $\gamma=1$, then expectations are fully adaptive and if $\gamma=0$, then the expectations are fully rational and based only on the inflation target set by the Central Bank.

### 7.1.5 *The Monetary-Policy Rule with Zero Bound*

$$i_t = \max \{0, \rho + E_t\pi_{t+1} + \theta_\pi (\pi_t - \pi_t^{target}) + \theta_Y Y_t^{gap} + \Delta_t^{monet} \}$$

This model summarizes monetary policy by a Taylor rule except the fact that it puts a zero bound on it. That means that the nominal interest rate cannot be less than zero even when the Taylor rule implies a negative rate. $\theta_\pi$ and $\theta_Y$ are coefficients chosen by the Central Bank to show how responsive the nominal interest rate could be to the variations in inflation and output gap respectively. They equal 0.5 in both this and Mankiw's model. The inflation target is the same as in Mankiw's model and it equals 2%.

Another difference from Mankiw's model is that the authors included a term ($\Delta_t^{monet}$) in this equation that represents deviations of monetary policy from the Taylor rule. This addition is due to the optimal monetary policy under full-information that will recommend fully offsetting demand-type shocks. This requires the monetary policy to be more active than the Taylor rule to shift the DAD curve back to the original position.

### 7.1.6 The Deviation from the Taylor Rule

$$\Delta_t^{monet} = (1-\delta)\,\Delta_{t-1}^{monet} + \delta(1/\alpha * \mathcal{E}_t^{demand} - \mathcal{E}_t^{risk})$$

In this equation $\delta \in [0,1]$ is a parameter that describes how much the Central Bank offsets demand-type shocks. When $\delta=0$ the Central Bank follows the Taylor rule and when $\delta=1$ the Central Bank fully offsets the shocks. If $\delta$ is between 0 and 1 that means that the Central Bank partially offsets shocks which might be caused by the unwillingness to change interest rates too quickly or just the fact that the Central Bank might not know the extent of the demand shock yet.

### 7.1.7 Okun's Law

$$u_t - u^n = -\beta Y_t^{gap}$$

Okun's Law, as mentioned in Mankiw's model, summarizes the negative relationship between unemployment and output level. In this model the natural rate of unemployment is set at 5% and $\beta=0.5$ that means that the unemployment rises by 0.5 percentage points when the output gap declines by a percentage.

### 7.1.8 Persistence of Shocks

$$\mathcal{E}_t^i = \omega_i\,\mathcal{E}_{t-1}^i + \eta_t^i$$

The authors assume that risk and supply shocks have only temporary effects on the economy. In this equation $\omega_i$ is the persistence parameter which varies between 0 and 1, where $\omega_i=1$ describes the scenario where there are

permanent shocks. $\eta_t^i$ is the innovation to the shock process for each i $\epsilon$ {demand/risk, cost}.

# CHAPTER 8

# EXPERIMENTS

## 8.1    Demand Shocks

### 8.1.1    Temporary Demand Shock with Adaptive Expectations

By definition, a demand shock is a sudden change in the economy which temporarily changes demand. If the shock is positive that means consumers assume that productivity will increase in the short-run and the demand will increase for a short period as well. If the shock is negative, meaning there is a temporary doubt about the economy, and then consumers temporarily decrease their demand. Usually surprise changes that could be considered as demand shocks are associated with consumers' preferences, tax rates, government spending, etc. For example, a temporary tax cut puts consumers in the position where they can consume more because they could keep surplus money through saving on taxes. This sudden positive change in their life increases their consumption capacity as well as demand on the market.

**Figure 1**
**Impulse Responses to a 5% Demand Shock with 0 Persistence Under Fully Adaptive Expectations (ɣ = 1) and No Deviations From the Taylor Rule (δ=0).**
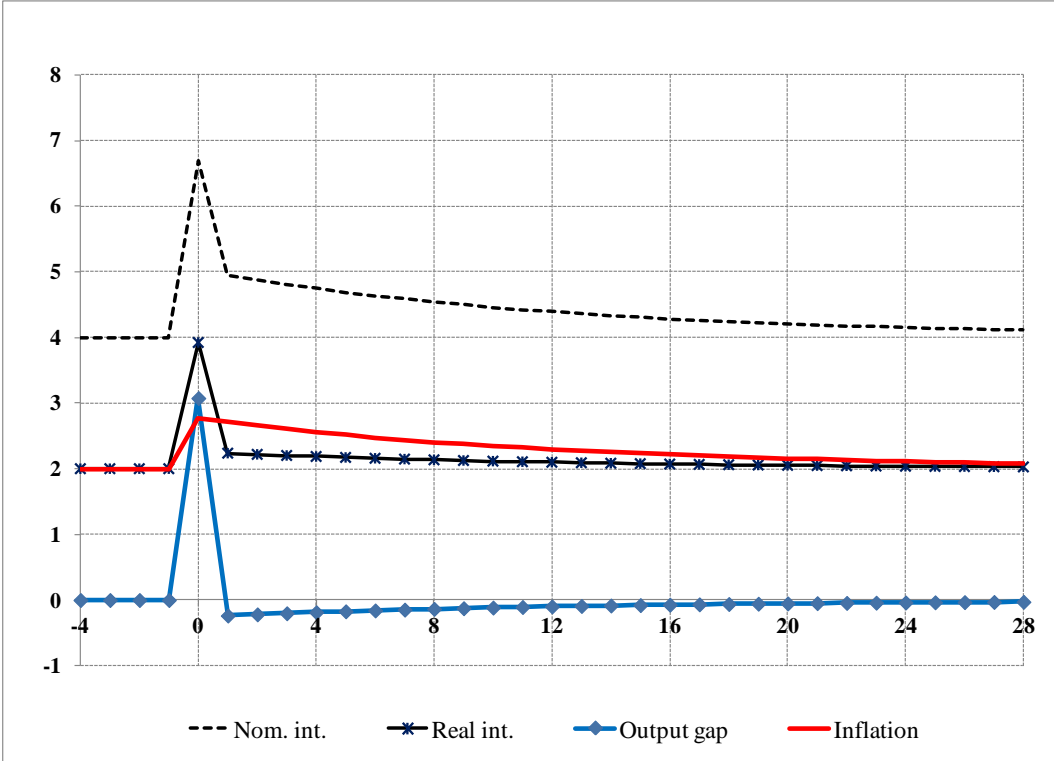


This positive demand shock causes current output to increase in the shock period because production increases. Increased demand for goods and services contributes to the increased prices which results in higher inflation than targeted by the Central Bank. High inflation rate and a positive output gap give incentives to the Central Bank to increase the nominal interest rate above the increase in expected inflation to keep the economy stable. Increased nominal interest rate transfers itself into the higher real interest rate so as to prevent the output gap from future increases.

For the following time period because of fully adaptive expectations and high inflation in the shock period expected inflation for the next period remains high. This causes inflation for the subsequent period to remain above the target inflation rate and keep nominal and real interest rates above the long-run equilibrium rates. Therefore, even after the demand shock reverts back to 0, the output keeps going below the natural level of output instead of going back to original position. This creates a negative output gap which remains for a prolonged period of time.

### 8.1.2  Expectations Impact – Demand Shocks

This section will describe whether changing the type of expectations has any impact on how the economy responds when we have demand shocks. To analyze the impact of rational expectations, I will assume that there is a 5% demand shock with 0.8 persistence. To compere the differences in the impulse response functions when we have adaptive and rational expectations, I will keep monetary policy following the Taylor Rule.

**Figure 2**
**Impulse Responses to a 5% Demand Shock with 0.8 Persistence Under Fully Adaptive Expectations (ɣ = 1) and no Deviations From the Taylor Rule (δ=0).**
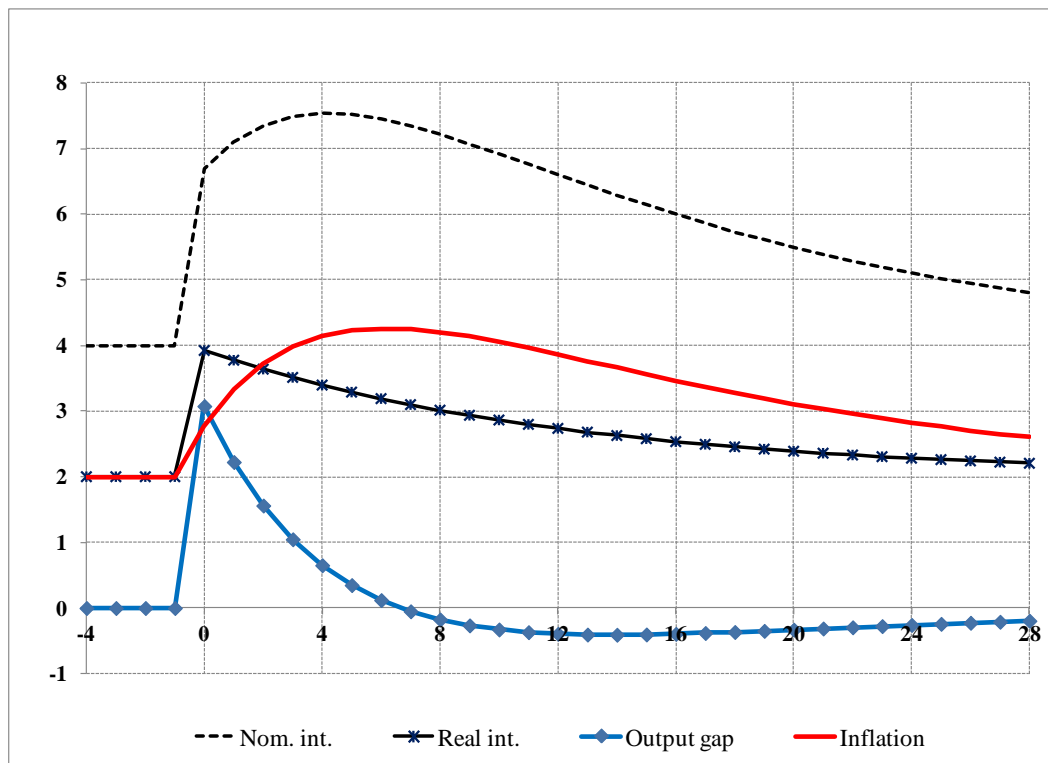


Figure 2 shows the scenario when the model assumes adaptive expectations. When the positive demand shock hits the economy, it means that economy suddenly becomes more productive and the output increases. High demand pushes up the price level in the economy which results in the higher inflation than that targeted by the Central Bank. In order to prevent inflation from subsequent growth, the Central Bank increases the nominal interest rate so as to increase real interest rate. Increasing the real interest rate will cause the output

gap to decrease. Because of the response from the Central Bank the output gap increases by the less than 5%.

The inflation rate keeps growing above the target inflation rate ($\pi=2\%$) owing to the adaptive expectations. The Central Bank raises the nominal interest rate above and beyond the increase in the expected inflation in order to make saving more attractive for people and as a result decrease demand. Slowly declining the demand has the opposite downward impact on the inflation through prices. Inflation keeps mounting until the increased nominal interest rate has a more powerful effect. After a certain amount of time, the inflation starts dropping along with the nominal interest rate to reach the target level.

The output gap starts decreasing after the shock period because, first, the real interest rate stays above the long-run target for a prolonged period of time and, second, expected high prices give incentives to people to decrease their demand for goods and services over the time. Even more, the output gap slowly decreases and goes below zero owing to continuous increase in the real interest rate and the expected inflation. After certain amount of time the output gap returns to its original position when the inflation and the interest rates approach to the long-run level.

Now I am going to show the impact of the incorporating the rational expectations in the same scenario. For the shock period there are not many differences. Figure 3 and Figure 4 represent scenarios with rational and fully rational expectations, respectively. The shock intensity is the same as in fully

adaptive case with only small difference in the less increase in the nominal

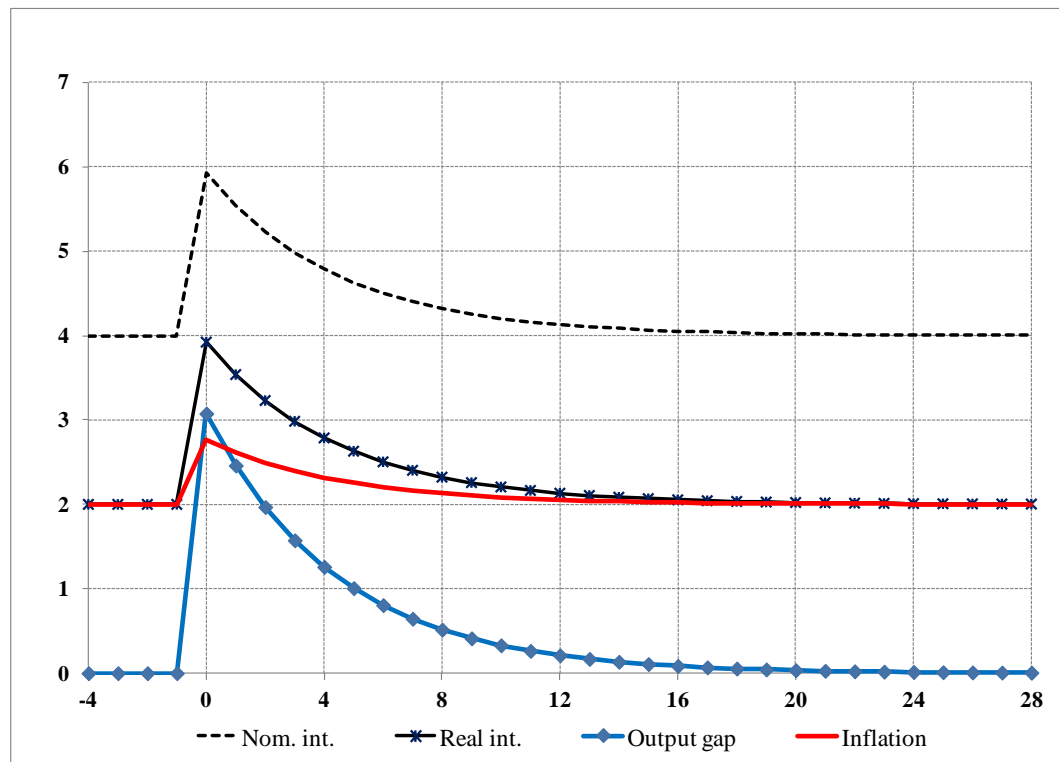interest rate in the shock period.

**Figure 3**
**Impulse Responses to a 5% Demand Shock with 0.8 Persistence**
**and Inflation Expectations Parameter ɣ = 0.5 and No Deviations**
**from the Taylor Rule (δ=0).**
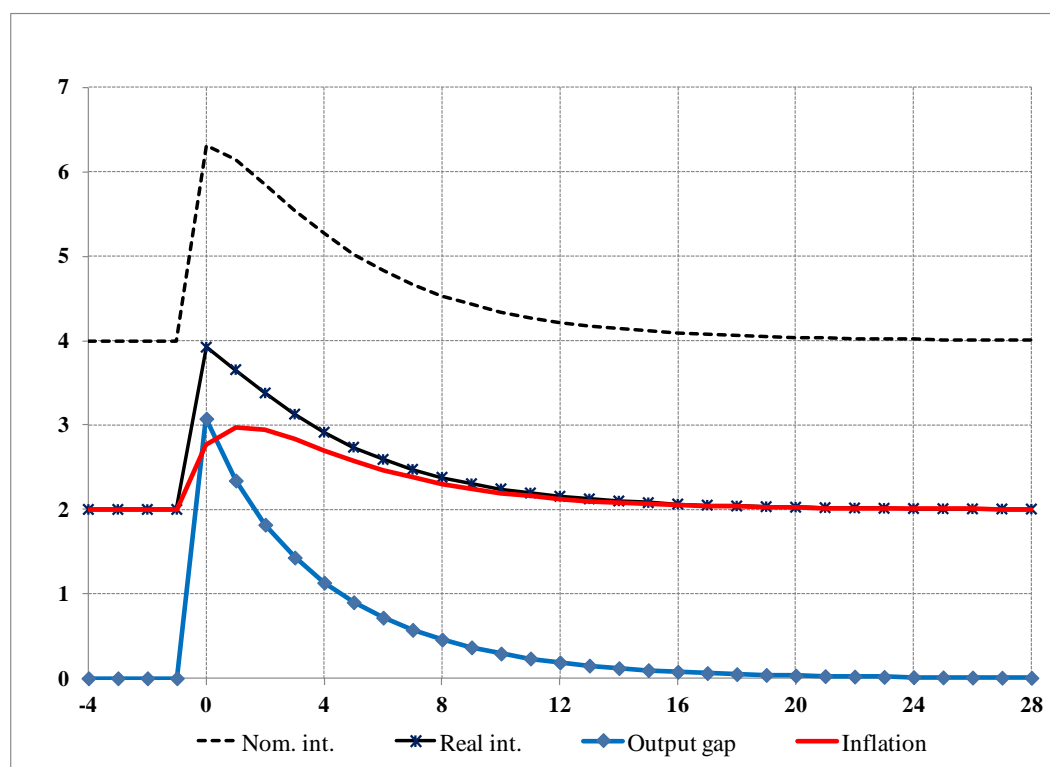


The output gap as it was expected increases in the shock period

because of high productivity and increased demand. High prices created by high

demand results in higher inflation and the Central Bank responds to the shock by

increasing the nominal interest rate in order to prevent the output gap from fully

increasing by 5%. However, the inflation starts decreasing right after the second

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quarter from the shock period because people form their expectations based on both the current inflation level and the Central Bank's target inflation rate. Consequently, the inflation rate does not continue to increase, in the contrary it rapidly returns to the target rate because people assume that the Central Bank will make sure that the inflation is not above the target rate for a substantial period of time. As a result, the Central Bank does not need to further increase the nominal interest rate and it slowly comes back to its original position.

**Figure 4**
**Impulse Responses to a 5% Demand Shock with 0.8 Persistence and Inflation Expectations Fully Based on the Credible Inflation Target (ɣ= 0) and the Central Bank Following the Taylor Rule (δ=0).**

The real interest rate rises in the shock period because of the increased nominal interest rate but, unlike the adaptive expectations case, after the shock period it more rapidly declines to reach the target rate. As a result, we observe a different response to the shock over the time. In case of rational expectations, output gap never goes below zero because there is no continuous increase in the inflation rate and the nominal interest rate. Even more, in case of the fully rational expectations, inflation rate starts decreasing right after the shock period (Figure 4).

To sum up, considering adaptive expectations exaggerates the shock impact on output and, moreover, shows different results by generating recession after economic boom, this would lead policy suggestions into the wrong direction and conclusions would be mistaken assuming that people do use all their information resources to make decisions. Consequently, the rational expectations could give us more accurate results; analyzing the results is easier and conclusions would be more truthful.

### 8.1.3 Policy Impact – Demand Shock

When a demand shock hits the economy, it causes economy to have high production level. The consumption capacity increases suddenly and people have high expectations regarding future income, as a result increased demand on the market puts inflation and interest rates off track. In order to keep the economy stable the Central Bank need to respond to the shock. The Central Bank follows Taylor Rule as we mentioned and it increases the nominal interest rate more than

the increase in the expected inflation rate. Unfortunately, as we see in the Figure 5 the Central Bank cannot avoid the economic boom caused by the demand shock if it only follows the Taylor Rule. On the other hand, one might ask why the Central Bank should respond in this case at all since we have boom and the economy is better off.
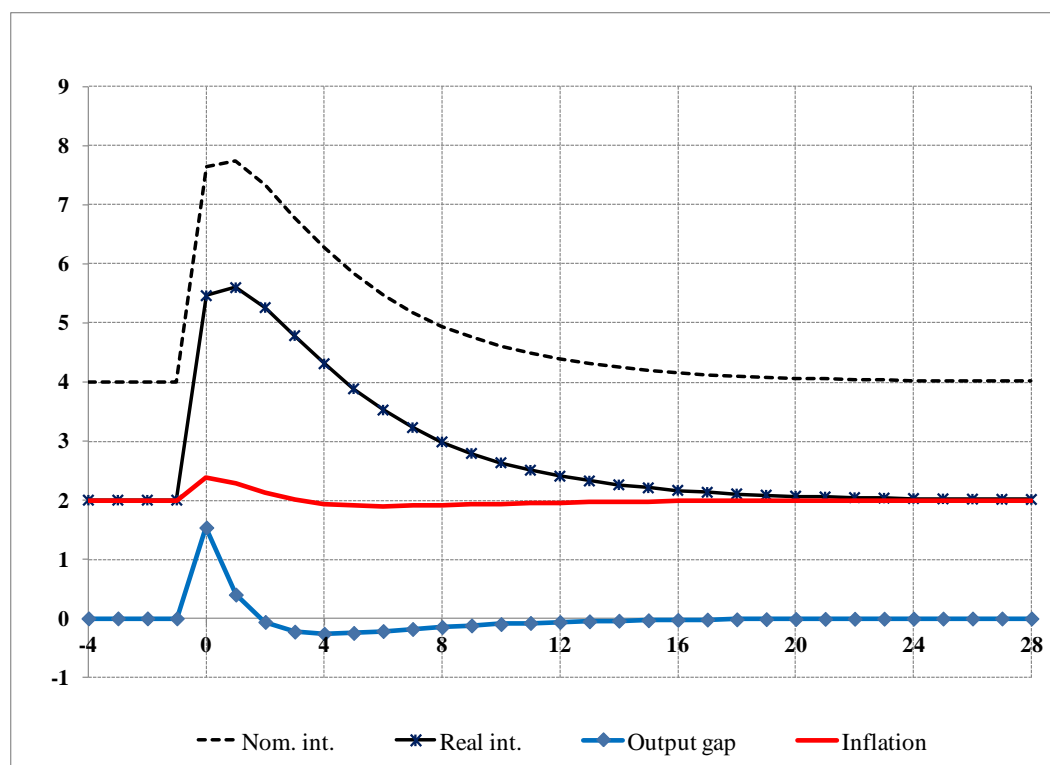
**Figure 5**
**Impulse Responses to a 5% Demand Shock with 0.8 Persistence and Inflation Expectations Parameter ɣ = 0.5 and No Deviations From the Taylor Rule (δ=0).**
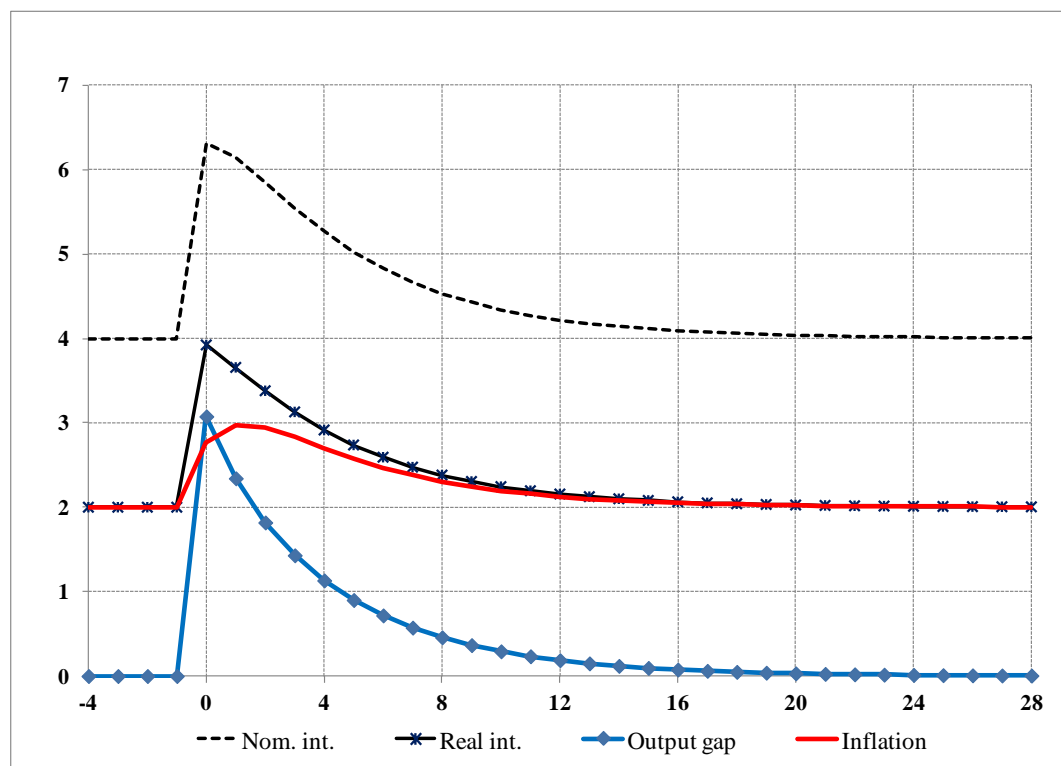


Although an economic boom is attractive in the short-run, efficient and optimal policy analysis suggests keeping the economy at the long-run level. To

observe whether the Central Bank can cope with the GDP and inflation fluctuations I will test two scenarios, one with the Central Bank partially offsetting the demand shock impact and, second with the Central Bank fully offsetting the shock.
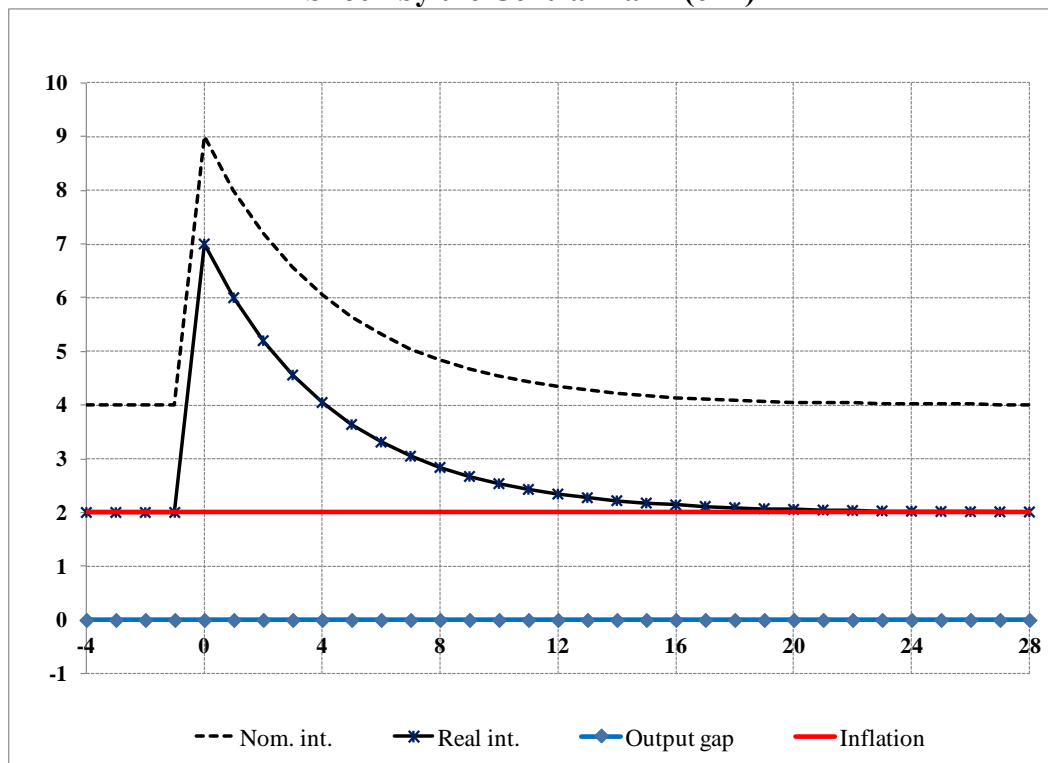
**Figure 6**
**Impulse Responses to a 5% Demand Shock with 0.8 Persistence**
**and Inflation Expectations Parameter ɣ = 0.5 and with Gradual Offsetting**
**of the Shock by the Central Bank (δ=0.5)**



In Figure 6 the Central Bank tries to partially offset the shock impact and we have several results which are different from the previous scenario. At first, the output gap started returning to its original position quicker and the level of the

boom was not as high as in the Figure 5. However, it decreased below zero instead of staying at the long-run level. That means, the Central Bank caused economic bust after the economic boom by interfering in recovery process. The shock was high and the Central Bank had to drastically increase the nominal interest rate so that it could prevent the output gap from subsequent increase. This contributed to higher inflation expectations for a prolonged period of time, which on its own caused the decreased demand on the market more and beyond what is needed to reach a zero output gap. It took time to realize that the Central Bank was bringing the interest rates down; meanwhile the high inflation expectations caused low productivity in the economy until it reached the original position.

**Figure 7**
**Impulse Responses to a 5% Demand Shock with 0.8 Persistence
and Inflation Expectations Parameter ɣ = 0.5 and with Fully Offsetting of the
Shock by the Central Bank (δ=1)**



In Figure 7 the Central Bank fully offsets the demand shock, in other words, raises the nominal interest rate to prevent the output gap from crisis. Consequently, there is no change in output or in the inflation rate at the expense of high interest rates.

In the end, one can assume that the Central Bank needs to decide whether to interfere at all, because its interference might cause either economic stability or economic bust. Eventually, it might be better the Central Bank to avoid any kind

of policy interruption and let the economy return to its original position on its own if there is a demand shock.
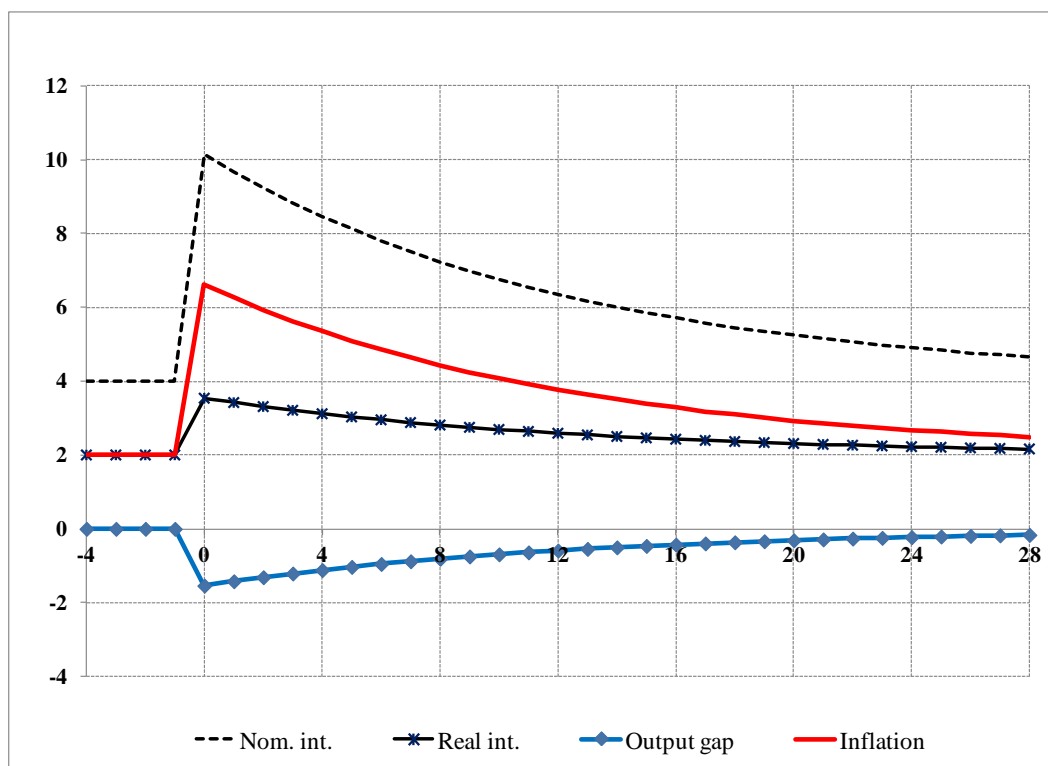
## 8.2    Supply Shocks

### 8.2.1    Temporary Supply Shock with Adaptive Expectations

A supply shock is a sudden change in the supply of products or commodities on the market, which causes sudden change in the price level. Supply shock as well as demand shock can be positive and negative. A negative supply shock means that something happened in the economy which suddenly decreased supply of products and this resulted in higher prices. Usually unpredicted changes such as any natural disasters, price manipulations from the cartels and syndicates any other unanticipated event which disturbs supply side of production are considered as supply shocks. For example, if OPEC decides to increase oil prices that would have a negative impact on the production in each sector, which means supply would decrease and prices would escalate.

Figure 8 represent a temporary 5% supply shock under the adaptive expectations.

**Figure 8**
**Impulse Responses to a 5% Supply Shock with 0 Persistence**
**Under Fully Adaptive Expectations (ɣ = 1)**



Supply shock causes scarce supply resulting in high prices which boosts inflation rate in the shock period. In order to prevent prices from consequent increases the Central Bank raises the nominal interest rate by more than shock impact. The nominal interest rate has an impact on the real interest rate and causes it to rise. As we know there is an inverse relationship between the real interest rate and the output gap, in other words, high real interest rate will cause current output to decline and results in the negative output gap. Because of adaptive expectations the inflation rate remains higher than the targeted inflation rate, although because

of the negative output gap the inflation growth rate decreases over time until it reaches the target and as a result negative output gap reverts back to the original position.

### 8.2.2  *Expectations Impact – Supply Shock*

I will describe a scenario when there is a 5% supply shock with 0.8 persistence in order to observe whether the expectations have any impact on how the economy responds to the cost shock. Scarcity of products causes prices to increase which results in high inflation for the shock period. If model assumes inflation expectations fully based on the credible inflation target, then the inflation rate does not increase by the full 5% because the Central Bank pulls it down by increasing nominal interest rate so as to increase the real interest rate as well. As a result we don't have full 5% decrease in output because people are fully rational and they assume that this inflation is temporary and they believe that the Central Bank is going to bring the inflation back to the target rate (Figure 9).

**Figure 9**
**Impulse Responses to a 5% Supply Shock with 0.8 Persistence and Inflation**
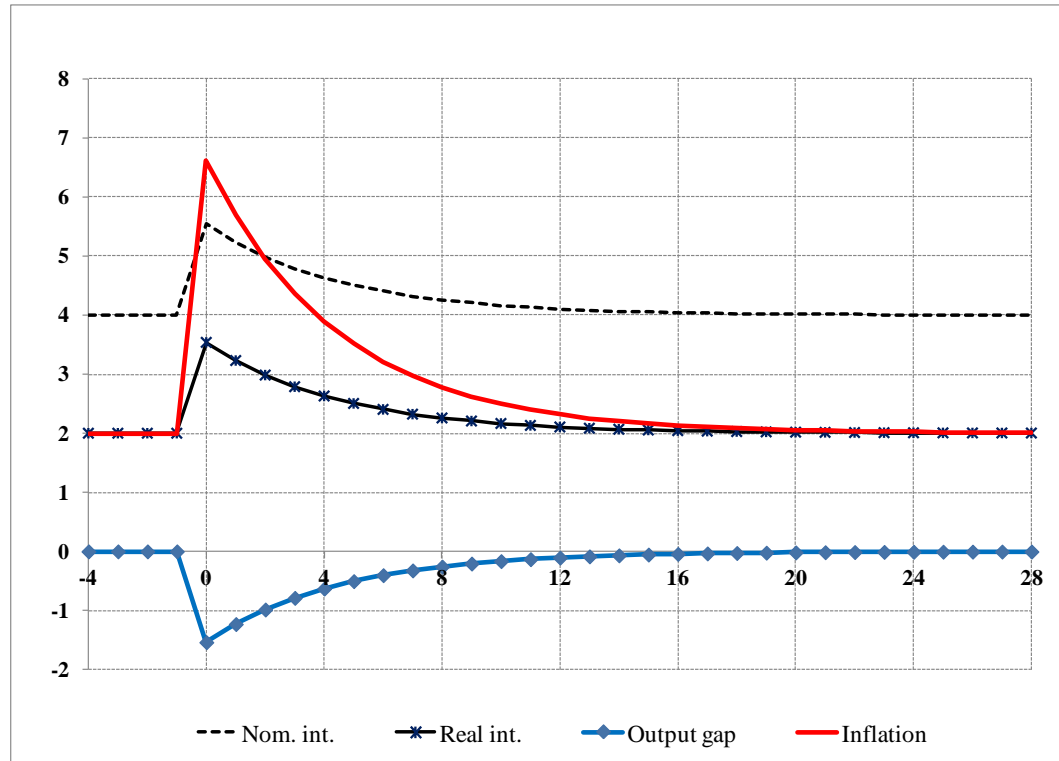**Expectations Fully Based on the Credible Inflation Target (ɣ= 0).**



Figure 9 describes the impulse responses to a 5% supply with 0.8 persistence and inflation expectations fully based on the credible inflation. As this graph shows, at the shock period inflation increases suddenly, this prompts the Central Bank to increase the nominal interest rate so as to increase real interest rate as well which drops output gap below zero. Negative output gap ensures that the increase in inflation in the shock period is less than 5%. Because this shock is persistent first time increase in inflation is less than 5%. This causes the same level increase in the real interest rate as it decreases output gap. After the shock

period, inflation rate gradually returns to its long-term level (2%) because of fully rational expectations. Eventually output gap returns to its original position along with gradual decrease in the interest rates.

To explore the impact of the expectations on the responses in the economy, model can be set at the level that considers rational expectations, which are formed partially based on past inflations and partially based on the target inflation rate (Figure 10 &11).

**Figure 10**
**Impulse Responses to a 5% Supply Shock with 0.8 Persistence**
**and Inflation Expectations ɣ= 0.5.**
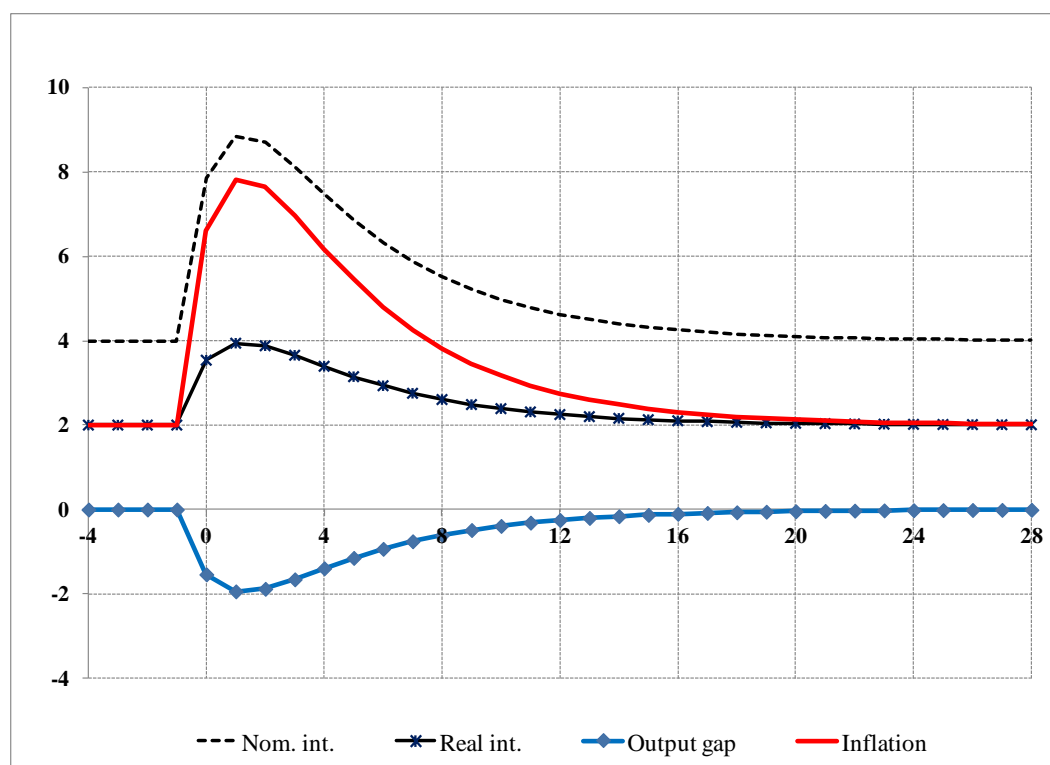
In the Figure 10 we have the supply shock which has the same size; the only difference is that now model assumes rational expectations. In this case inflation rate expectations depend on both past inflation rates and inflation target set by the Central Bank. It is easy to notice that the response from the economy in this scenario is different. Instead of a sudden increase in inflation, it reaches its peak in two quarters from the shock period. Gradual increase is caused by the fact that current inflation participates in forming the expectations for the future, as a result high inflation rate in the shock period results in higher inflation in the following year. Accordingly, the Central Bank increases nominal interest rate gradually to prevent the inflation from the subsequent raise. Consequently, we see slow reduction in the output gap until reaching the lowest level and then gradually returning to its original position. Interest rates are adjusted accordingly as well. The characteristics of the recovery period are different as well because of incorporating rational expectations. In this case the participation of the past inflation level causes extended recovery period in addition to the shock persistence, as a result it takes longer for the economy to return to the original position.

To finish analyzing the impact of expectations, I will present the scenario when people have fully adaptive expectations, holding the rest fixed.

**Figure 11**
**Impulse Responses to a 5% Supply Shock with 0.8 Persistence**
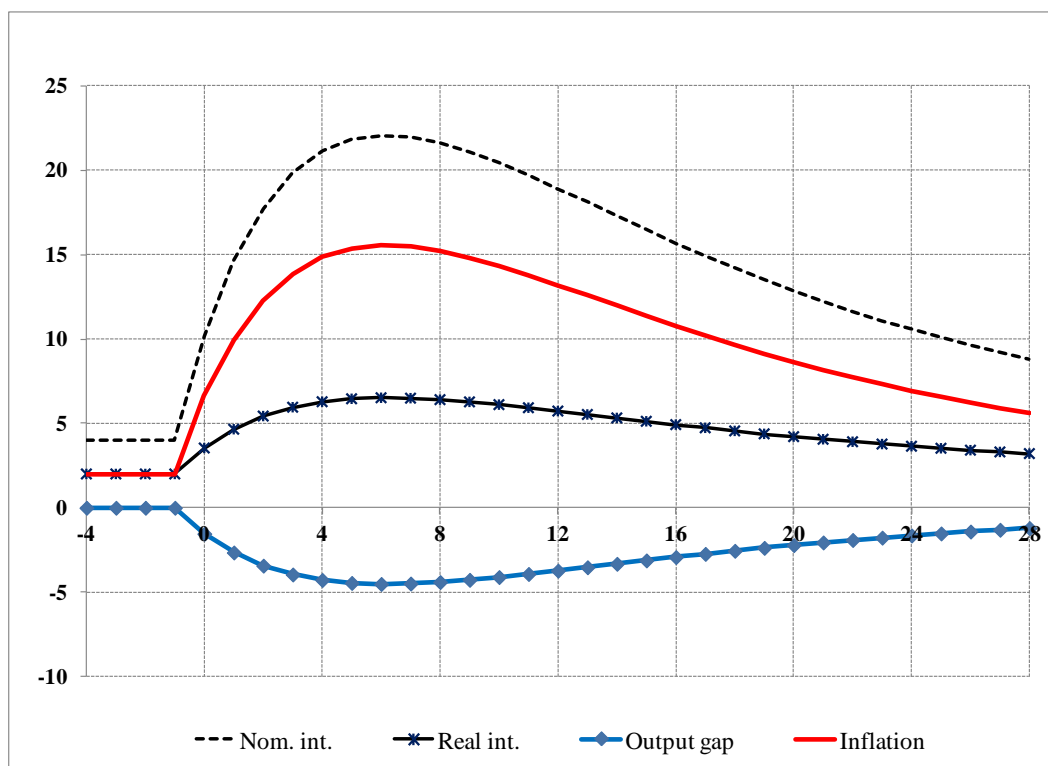**Under Fully Adaptive Expectations ($ɣ = 1$)**



Figure 11 shows the impulse responses to the supply shock under the fully adaptive expectations, meaning, people assume that the inflation rate in next period will be equal the inflation rate in the current period which is the same as the inflation rate in the previous period of time. This figure captures that economy with fully adaptive expectations behaves differently from the fully rational case. We do not observe abrupt escalation of the inflation; instead it steadily reaches its peak after year and a half. The Central Bank accordingly adjusts the nominal interest rate to affect the real interest rate so as to shrink the output gap. In

addition, model captures that the volume of the impact of the shock is intensified as well. In this case inflation increases by more than 5% and the output gap almost reaches negative 5%. As a result, because of adaptive expectations coupled with the persistence level of the shock the recovery period is extremely extended compared to the recovery period under the fully rational expectations.

To sum up, observing the 5% supply shock with 0.8 persistence under different levels of the rational expectations showed the impact of the ways people form their anticipations about future inflations. The first obvious difference is the severity of the shock; assuming adaptive expectations exaggerates the severity of the shock, whereas incorporating rational expectations in the model helps to present better predictions regarding the economy. Moreover, the pattern of the recovery period is different as well. Rationality prevents the long lasting shocks and it takes less time to recover under rational expectations compered to adaptive expectations, holding the rest fixed.
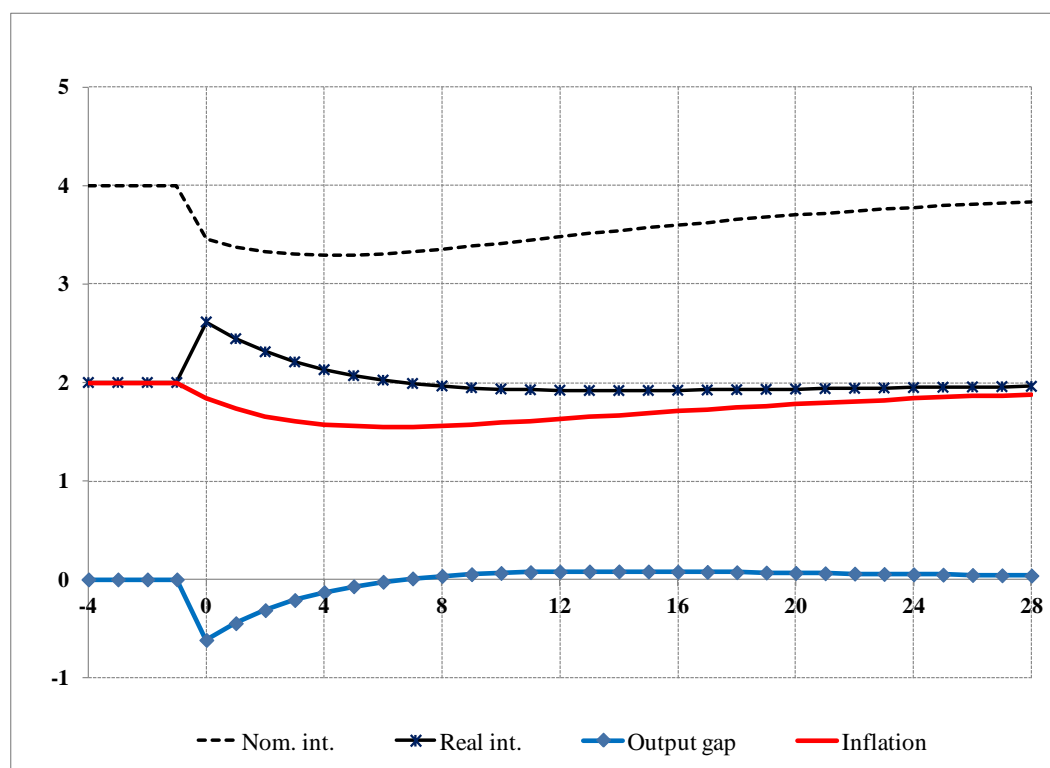
## 8.3    Risk Shocks

### 8.3.1   Expectations Impact – Risk Shock

A risk shock is a sudden change in the economy which causes a change in people's attitude towards the safety of investing. Risk shock means a lower marginal efficiency of investment and as a result they decrease investment in the economy. Consequently, risk shocks are strongly negatively correlated with output gap; meaning, risk shocks cause less investment and less output in the

economy. Risk shocks could be represented by any sudden changes in the economy which increases a real interest rate and creates higher opportunity cost for spending.

Figure 12 represents the economy's response to a 1% risk shock with 0.8 persistence and the Central Bank following the Taylor Rule.

**Figure 12**
**Impulse Responses to a 1% Risk Shock with 0.8 Persistence**
**and Fully Adaptive Inflation Expectations ($\gamma= 1$) and the**
**Central Bank Following the Taylor Rule ($\delta=0$).**



The risk shock implies that the investment becomes riskier and as a result the price of the investment (the real interest rate) increases in the shock period.

Increased interest rate results in the less investment which on its own causes the output to shrink. Less output means less income which causes diminished demand. Consequently, we observe a lower price level resulting in an inflation rate below the target rate. In order to encourage spending and prevent output gap from subsequent decreases, the Central Bank decreases the nominal interest rate. This partially offsets the risk shock effect on the real interest rate and, hence, the output gap decreases by less than 1%.

After the shock period the economy slowly recovers from the shock effects and returns to its original position, which means that the output gap, inflation and interest rates return to their long-run level.

Figure 13 and Figure 14 represent the responses to the risk shocks after incorporating rational expectations and fully rational expectations, respectively. These figures show that there are not any crucial differences in the response patterns. The impact on the real interest rate is the same whether it is adaptive or rational expectations.

**Figure 13**
**Impulse Responses to a 1% Risk Shock with 0.8 Persistence and Inflation**
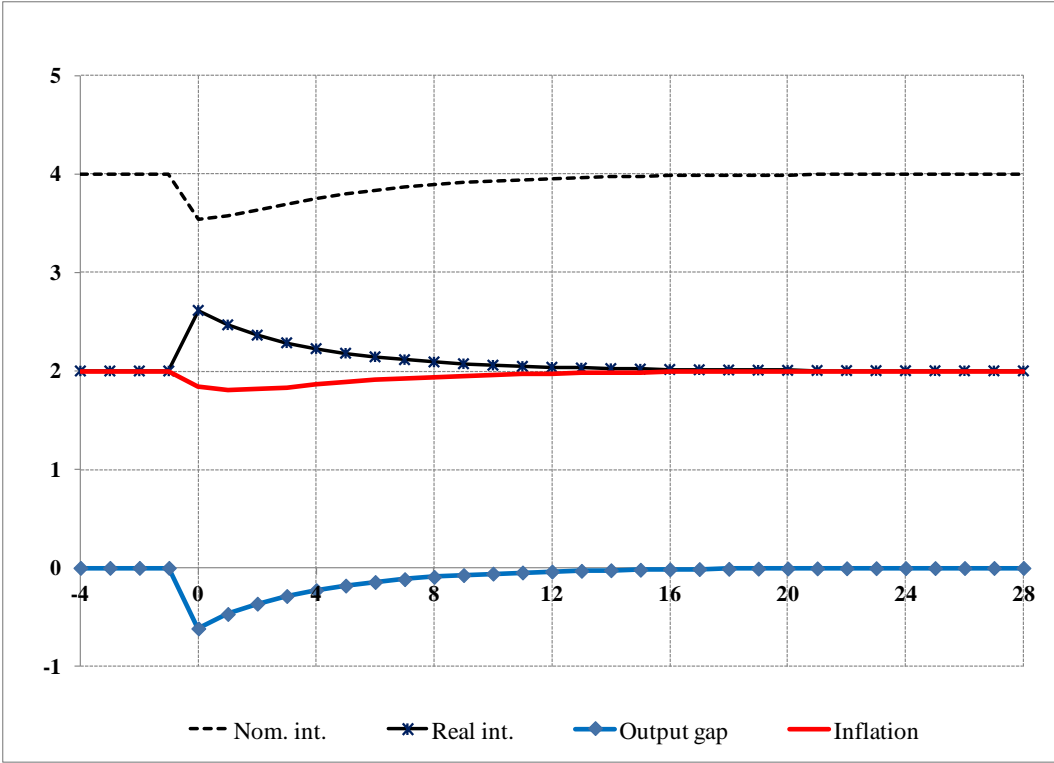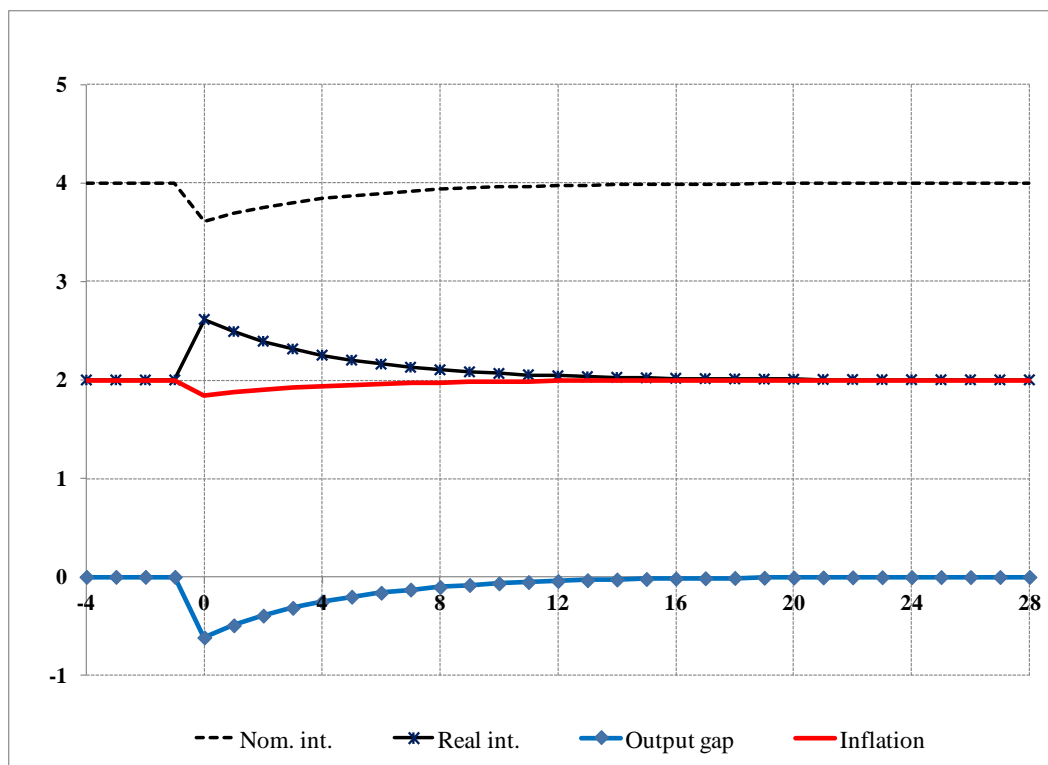**Expectations Ɣ= 0.5 and the Central Bank Following the Taylor Rule (δ=0)**

**Figure 14**
**Impulse Responses to A 1% Risk Shock with 0.8 Persistence
and Inflation Expectations Fully Based on the Credible Inflation Target
(ɣ= 0) and the Central Bank Following the Taylor Rule (δ=0).**



One difference is that the adaptive expectations exaggerate the response of the inflation rate and the nominal interest rate. Under the adaptive expectations the inflation rate and the nominal interest rate drop lower than under the rational expectations and it takes the economy longer to reach the long-run level of the inflation and interest rates because people keep forming their expectations based on the current inflation rate rather than considering the target inflation rate as well. Another difference is that, under the adaptive expectations output recovers more quickly from the risk shock rather than under the rational expectations.

*8.3.2    Policy Impact – Risk Shock*

In the case of a risk shock there is sudden change in investment that will cause a downturn in GDP and the economy might be off track for a prolonged period of time. This causes the pessimistic expectations in the society and the recovery period becomes more difficult. The only way that the economy can be stabilized is if the Central Bank can implement purposeful policies in response to the shock in order to offset its impact on the GDP. To analyze how much the Central Bank can manipulate with its policies to bring the economy back to its original position, I will look at the scenario when there is 5% risk shock with 0.8 persistence and people have rational expectations, meaning they set their expectations partially based on the past inflation and partially based on the target inflation rate.

At first I will look at the case when the Central Bank follows the Taylor Rule. The Taylor Rule shows how averse to fluctuations in inflation and output gap the Central Bank is. By definition, the Taylor Rule gives the same weight to the Central Bank's responsibeness towards inflation and the output gap. In other words, the Taylor Rule states that the response coefficients of the Central Bank to both deviations of inflation ($\theta_\pi$) from its target and the output gap ($\theta_Y$) equal to 0.5. Using the Taylor Rule the Central Bank is supposed to decrease the nominal interest rate more than the decrease in expected inflation rate.

**Figure 15**
**Impulse Responses to a 5% Risk Shock with 0.8 Persistence and Inflation Expectations Ɏ= 0.5 and the Central Bank Following the Taylor Rule (δ=0).**
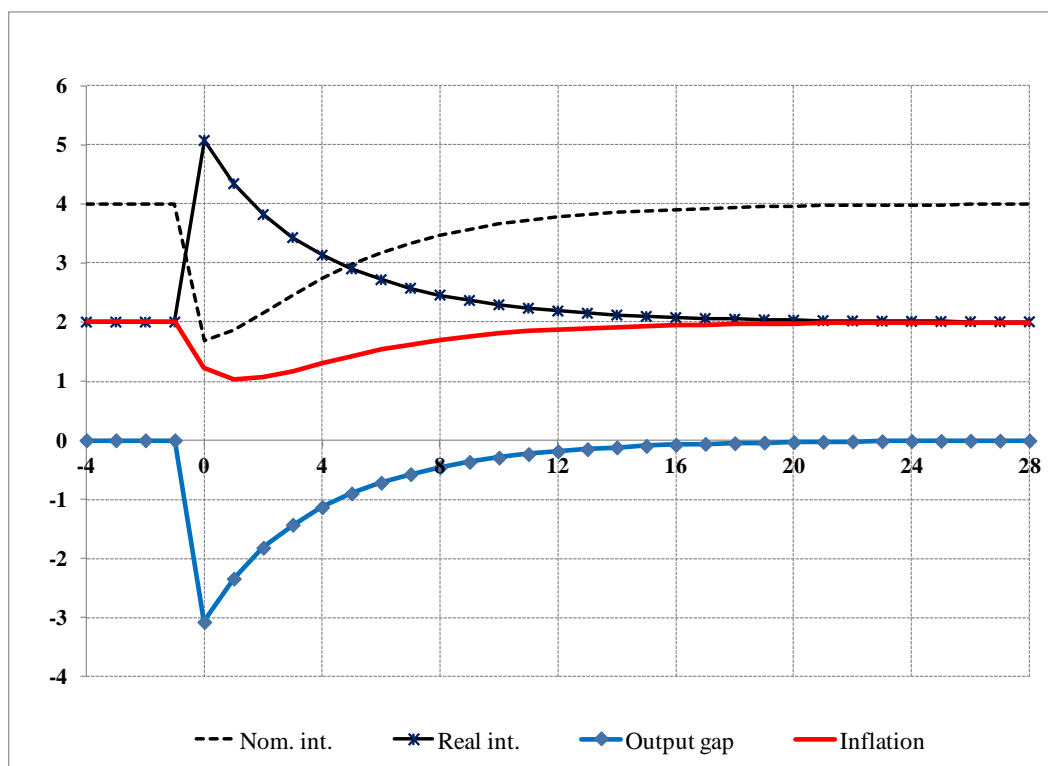


This is exactly what Figure 15 shows. The Central Bank does not offset the risk shock impact and as a result, we have sudden drop in the output gap along with a higher real interest rate. As this figure shows it takes a prolonged period of time to fully recover from the economic recession caused by the risk shock. If we would like to suggest optimal policy it would require the Central Bank to fully offset the shock impact, but, the Taylor Rule does not do that. This means there could be an opportunity for the Central Bank to deviate from the Taylor Rule to secure efficient and optimal policies for the economy.

**Figure 16**
**Impulse Responses to a 5% Risk Shock with 0.8 Persistence and**
**Inflation Expectations Ɣ= 0.5 and with Gradual Offsetting of the**
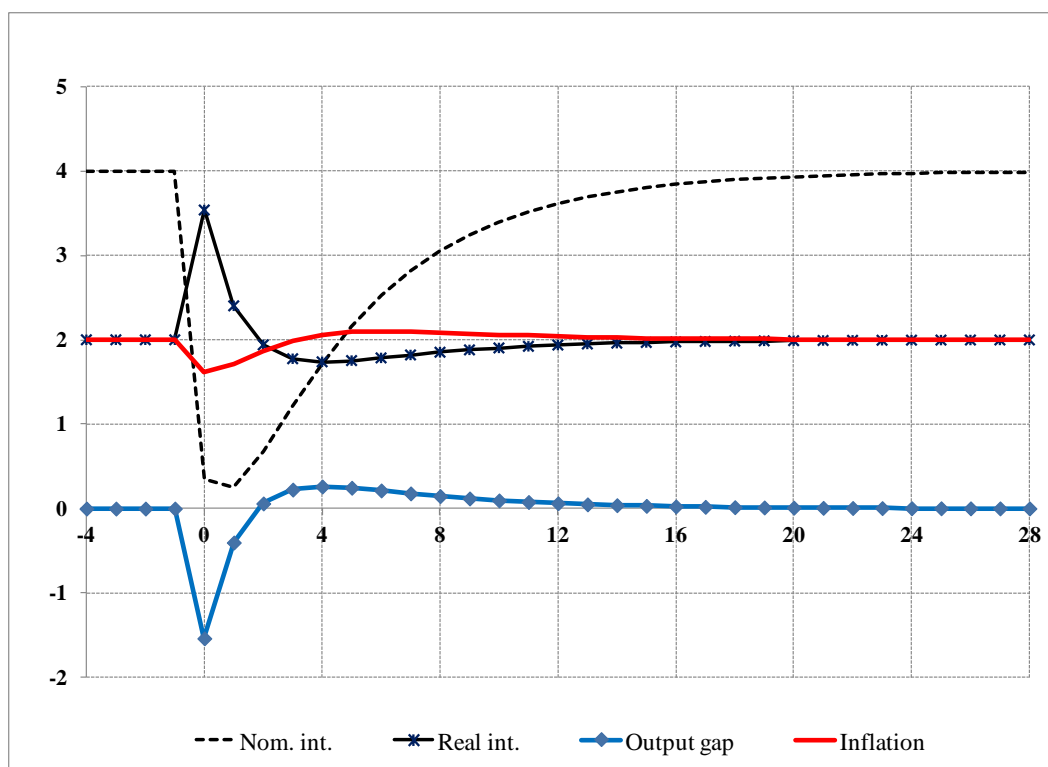**Shock by the Central Bank (δ=0.5).**



Figure 16 shows the scenario when the Central Bank partially offsets the initial risk shock impact. The Central Bank decreases the nominal interest rate even more than the Taylor Rule requires. One can observe several obvious differences. First of all the severity of the shock impact is much smaller. Instead of 3% increase in the real interest rate and 3% decrease in the output gap, the graph only shows half of that impact on economy. The output gap was decreased by only 1.5% in the shock period. Not only that, owing to deviating from the Taylor Rule the Central Bank could create economic boom after the bust for about

one year before the output gap returned to its original position. In addition, the prominently shorter recovery period is due to the Central bank's deviation from the Taylor Rule as well.

**Figure 17**
**Impulse Responses to a 5% Risk Shock with 0.8 Persistence and Inflation Expectations Ɣ= 0.5 and with Fully Offsetting of the Shock by the Central Bank (δ=1).**



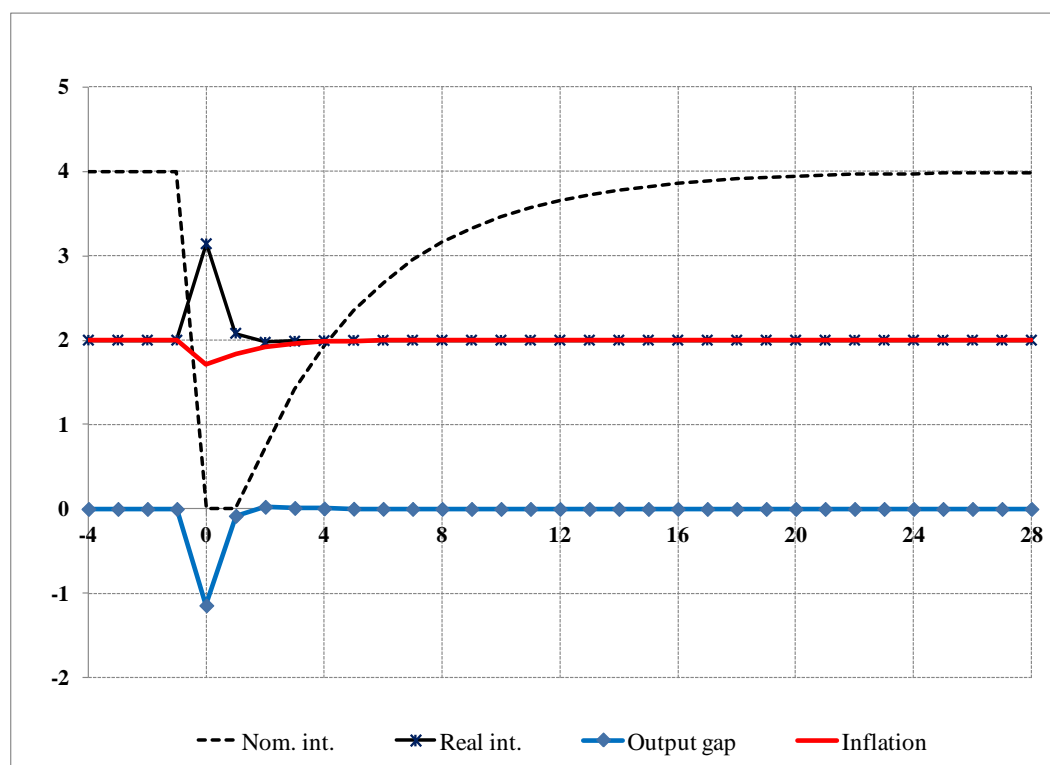Finally, look at the scenario when the Central Bank tries to fully offset the risk shock impact (δ=1). This case is interesting in terms of analyzing the Central Bank's ability fully offset the risk shock impact. The volume of the shock is pretty high (5%) which requires drastic decrease in the nominal interest rate in

order to fully offset the risk shock and keep the economy at the long-run level. As Figure 17 shows the output gap reconciliation requires the Central Bank to decrease the nominal interest rate below zero. This is impossible to incorporate in this model because of zero bound on the interest rates. Consequently, the Central Bank cannot decrease the nominal interest rate below zero and the output gap goes down around by 1%. On the other hand, the purposeful decrease in the nominal interest rate to equal zero achieved the Central Bank's object to quickly restore the economy.

As one can see from these three examples above, monetary policy analysis has an important role in the model to create suggestions regarding economy. The economic stability significantly depends on the Central Bank's responsiveness to the fluctuations in the inflation rate and output gap. This model has a flexibility to incorporate different levels of the Central Bank's responsiveness and as a result represent more realistic and accurate results, because the Central Bank follows interest rule.

## CHAPTER 9

## CONCLUSION

Facing the Great Depression made Keynes to analyze governments' credibility in responding to economic downturns. Keynes' *General Theory* made a great impression because it created a theory that could be easily applied and included manageable recommendations for the government to tackle recessions. In general, Keynesian theory was in favor of interventionist government policy and he argued that "animal spirits" run the decisions of society. Keynes mentioned that expectations could have an impact on the economic activities, although it was inconsequential for policy analysis. The Keynesian school of economics focused only on the short-run analysis and its main goal was to understand the nature of the economic downturn and find applicable policies which could have an instant impact on the economy.

Since Keynes did not have an extensive mathematical model in his *General Theory*, Hicks and Modigliani created a mathematical model for Keynesian theory. Their IS-LM model was simple and elegant, which could separate the monetary sector from the savings-investment sector enabling easier policy analysis. In 1960s and 1970s IS-LM model was a crucial tool for economic analysis – it combined the Keynesian and classical models so that it became the

fundamental framework for both policy debates and theoretical work in economics. The main goal of the model was attained; IS-LM represents simple framework for discussing economic policies and it is easy enough to be used as a "back of the envelope tool."

Colander argues that IS-LM analysis is "a creature of pedagogy" (Colander, 2004, p.305). In the 1960s the IS-LM model was a stepping-stone to higher economic studies. The goal of the model was to ensure that students could learn more about macroeconomic activities, monetary and fiscal policies and the problems of long and short run policies. Mainly, the IS-LM framework is intuitive and easy to explain to students who do not have a sophisticated math background and are interested in macroeconomic policy effects. In addition, it is easier for policy-oriented economists to discuss and represent their ideas about policy impacts and government intervention strategies.

Something was missing that made IS-LM outdated after couple of decades. First of all, the rational expectations revolution brought the idea that expectations have to be included in economic analysis if one wants to generate realistic and accurate results. Especially, if we consider one of the model's goals is to enable policy analysis, IS-LM looses credibility because it does not reflect people's behavior and neglects the fact that people change their response strategies when government implements new policies. The IS-LM model degenerated because it ignored the importance of the rational expectations and analyzed people as if they act under the new policy environment just as they would act before the policy

implementation. Secondly, IS-LM model is too simple and LM curve does not incorporate the idea that the government can be more active than just following the Taylor Rule. Thus, Keynesian assumptions regarding policy interventions were wrong. We need more dynamic models which allow predictions to change and analyze the impacts of the policies under flexible nature of expectations and more active government.

In order to be considered as a successful model, the new model should have several competitive advantages. The ultimate goal is to represent realistic results and to be close to reflecting real economic changes. In order to be able to accurately show the consequences of different economic shocks, the model needs to include realistic variables and the most important is to include variable which will be a proxy for the rational expectations. In reality, the Central Bank follows the interest rate rule rather than directly targeting money supply. This creates a need to incorporate an equation which would represent monetary policy in the model and, moreover, it should describe actively involved government. In addition to this, the model needs to be simple, elegant and easy to understand in order to be successfully accepted both in academia and among economists.

I represented several crucial modifications in the new Amherst model, such as including a more flexible form of establishing consumers' inflation expectations, allowing monetary policy to deviate from the Taylor rule in order to capture a more realistic situation, incorporating zero bound and adding additional risk shock. This made the model more dynamic and enabled the framework to

better show the nature of the shocks and the monetary policy impacts on the economy. What is different and advantageous about this model is that it can combine both the former and current trends of the model building. In other words, this model has both rational and adaptive expectations and it can show both results; this model can show the economic impulse responses both when the Central Bank follows the Taylor rule and partially or fully offsets the economic shocks. This gave me an opportunity to observe similarities and differences in response patterns under the same circumstances.

After testing several dozen of experiments and picking interestingly distinct results, I focused on the importance of incorporating the rational expectations, the impact of more active monetary policy during three different economic shocks: demand, cost-push and risk shocks.

As it was expected rational expectations cases were drastically different from the cases assuming adaptive expectations. One thing was true in all cases, considering adaptive expectations exaggerates the shock impact on output, whereas incorporating rational expectations in the model helps to present better predictions regarding the economy. Moreover, adaptive expectations shows different results by generating recession after economic boom in case of the demand shock. In addition, the pattern of the recovery period is different as well. In case of cost-push shocks, for example, rationality prevents long lasting shocks and it takes less time to recover under rational expectations comparing to adaptive expectations. Mistakenly assuming adaptive expectations would lead policy

suggestions into the wrong direction and conclusions would be in error. In my opinion, the rational expectations could give us more accurate results; analyzing the results is easier and conclusions would be more truthful.

Allowing the monetary policy to deviate from the Taylor rule has an important role in policy suggestions as well. The economic stability significantly depends on the Central Bank's responsiveness to the fluctuations in the inflation rate and output gap. In case of cost-push shocks, for example, the Central Bank needs to decide whether to interfere at all, because its interference might cause either economic stability or economic bust. This model has a flexibility to incorporate different levels of the Central Bank's responsiveness and as a result represent more realistic and accurate results.

To sum up, the new Amherst model proved that the IS-LM is outdated and it can be replaced in both academia and economic empirical work. This model proves that analyzing the results is easier and conclusions would be more truthful under the rational expectations and more active government. As expected, this model is able to represent more realistic and accurate results than prior models and, moreover, it is simple enough to be implemented in pedagogy and to be used in the policy analysis.

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