ANALYSIS OF INFLATION DYNAMICS IN TURKEY: A NEW KEYNESIAN PHILLIPS CURVE APPROACH

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ABSTRACT

ANALYSIS OF INFLATION DYNAMICS IN TURKEY:
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The main aim of this thesis is to explain the inflation dynamics in Turkey within a theoretically consistent empirical framework. The New Keynesian Phillips Curve (NKPC) is chosen as the basis model for our analysis because, by describing the inflation process within an intertemporal optimizing dynamic general equilibrium model, it provides a rigorous analytical groundwork for credible welfare and policy analysis. We have contributed to the literature by developing a NKPC formulation that is novel in the literature: A constant elasticity of substitution (CES) type of production function incorporating imported and domestically produced intermediate goods was combined with incomplete exchange rate pass through to import prices. The short-run inflation dynamics were analyzed within the context of this new specification by estimating the model's highly nonlinear structural parameters that capture the price-setting behavior in Turkey for period 1988:1 - 2009:4. Our findings suggest that this NKPC formulation can explain the 1994 and 2000-01 crises as well as the current environment of low inflation achieved with the adoption of the implicit and fully fledged inflation targeting regimes quite well. As a policy application we explored the effects of the inflation targeting framework adopted after the 2000-01 crises on the parameters characterizing the inflation process in Turkey. The subsample econometric results suggested that the inflation targeting framework applied was quite successful in decreasing inflation inertia in Turkey. Thus, should the success of the inflation targeting regime continue, this should be taken as an opportunity to reduce inflation substantially with very low output losses.

Keywords: New Keynesian Phillips Curve (NKPC), Exchange Rate Pass Through, Inflation Targeting, Continuous Updating GMM (CU-GMM).

ÖZ

TÜRKİYE'DE ENFLASYON DİNAMİKLERİNİN ANALİZİ:
YENİ KEYNESGİL PHİLLİPS EĞRİSİ YAKLAŞIMI

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Bu tezin esas amacı Türkiye'deki enflasyon dinamiklerini teorik olarak tutarlı bir ampirik çerçevede açıklayabilmektir. Yeni Keynesgil Phillips Eğrisi enflasyon sürecini zamanlararası optimizasyona dayanan dinamik bir genel denge modeli çerçevesinde tanımlayarak güvenilir politika ve refah çözümlemesi için sağlam bir analitik bir altyapı oluşturduğu için bu analizin dayandığı temel model olarak seçilmiştir. Bu çalışmada daha önce uygulanmamış bir Yeni Keynesgil Phillips Eğrisi modeli geliştirilerek literatüre katkıda bulunulmuştur. Bu yeni modelde, ithal ve yerli ara malları içeren sabit ikame esnekliği (CES) tipi bir üretim fonksiyonu, ithal mal fiyatları için tam-olmayan döviz kuru geçişkenliği ile birleştirilerek; *yeni* bir Yeni Keynesgil Phillips Eğrisi formülasyonu geliştirilmiştir. Kısa dönemli enflasyon dinamikleri; bu yeni spesifikasyon çerçevesinde, modelin doğrusal-olmayan ve Türkiye'deki fiyat belirleme davranışlarını yakalayan yapısal parametreleri 1988:1 – 2009:4 dönemi için tahmin edilerek incelenmiştir. Bulgularımız göstermektedir ki geliştirilen Yeni Keynesgil Phillips Eğrisi formülasyonu hem 1994 ve 2000-01 krizlerini hem de örtük enflasyon ve açık enflasyon hedeflemesi politikalarıyla oluşturulan günümüzdeki düşük enflasyon ortamını makul bir şekilde açıklayabilmektedir. Politika analizi olarak, 2000-01 krizlerinden sonra uygulanan, gerek örtük gerekse de açık enflasyon hedeflemesi politikalarının, Türkiye'deki enflasyon yapısını niteleyen parametreler üzerindeki etkilerini inceledik. Alt örneklem ekonometrik sonuçlar göstermiştir ki Türkiye'de uygulanan enflasyon hedeflemesi politikaları hem enflasyon ataletini düşürmede hem de enflasyonu ileriye-dönük hale getirmede başarılı olmuşlardır. Bütün bunların gelecek için öngördüğü politika önermesi ise enflasyon hedeflemesinin başarısının devam etmesi durumunda, bu uygulamanın enflasyonu az çıktı maliyetiyle önemli ölçüde düşürmek için bir fırsat olarak kullanılabilecek olmasıdır.

Anahtar Kelimeler: Yeni Keynesgil Phillips Eğrisi, Döviz Kuru Geçişkenliği (Exchange Rate Pass Through), Enflasyon Hedeflemesi, Sürekli Güncellenen Genelleştirilmiş Beklemler Yöntemi (CU-GMM).

To my Son, UTKU ERUYGUR

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CHAPTER I

INTRODUCTION

Our main aim in this thesis is to explain the inflation dynamics in Turkey within a theoretically consistent empirical framework. The New Keynesian Phillips Curve (NKPC) is chosen as the basis model for our analysis. The so called NKPC describes the inflation process within a *dynamic general equilibrium* framework where *imperfectly competitive* firms face *constraints on price changes*. This framework integrates the Keynesian features of imperfect competition and nominal rigidities into a microeconomic founded dynamic optimizing model called the *new neoclassical synthesis* model. Allowing for both nominal rigidities and market imperfections in these models alters the transmission mechanism for shocks and also provides a more potent role for monetary and fiscal policy. In this way, one goal of this new strand of research is to provide an analytical framework that is relevant for policy analysis. These models are theoretically consistent, have explicit microeconomic foundations, are able to model risk and uncertainty, and provide a rigorous analytical groundwork for credible welfare and policy analysis. The NKPC is the crucial equation that describes the supply block of these models. It serves to estimate the model's structural parameters that capture price setting behaviour in an economy.

A crucial issue, however, is whether the NKPC is empirically relevant. The studies that have found empirical support for the NKPC are accumulating rapidly from all over the world. In particular, the studies of Galí and Gertler (1999), Galí, Gertler and Lopez-Salido (2001), Galí and Lopez-Salido (2001), Sbordone (2002), Balakrishnan and Lopez-Salido (2002), Genberg and Pauwels (2005), Batini, Jackson and Nickell (2005), Céspedes, Ochoa and Soto (2005), Muto (2006), Maturu, Kisinguh and Maana (2006) give empirical support for the NKPC using data from US, Euro area, Spain, UK, Hong Kong, Chile, Japan, and Kenya. However, Rudd and Whelan (2005a, 2005b, 2006, 2007), Lindè (2005), Bjørnstad and Nymoen (2008) and Dufour, Khalaf and Kichian (2006) argue that the NKPC fails to give a good description of the inflationary process in the U.S., OECD counties and Canada. Therefore, while the NKPC is argued to become the workhorse equation for describing short term inflation dynamics by some researchers, there is still an ongoing debate about its merits. Probably, no other relationship is causing so much discussion among macroeconomists and policy makers nowadays.

The parameter values that result from the estimation of the NKPC largely depend on the model specification used. Thus, the empirical success or failure of the NKPC depends very much on the way the microeconomic foundations are modeled. As the NKPC was originally conceptualized for a closed economy setting, it should be altered accordingly if it is to be estimated for an open economy like Turkey. External influences on inflation need to be taken into account to improve the validity of the results.

A few NKPC studies that are applied to Turkish data provide mixed evidence on the validity of this curve for the Turkish economy. When the Turkish literature was evaluated from a theoretical perspective by contrasting the modeling strategies used in these studies with our approach, the mixed empirical results were attributed to the diverse modeling approaches used in these studies. The NKPC models employed in the Turkish literature do not account for one or more key structural features of the Turkish economy (i.e. openness, high dependence of the costs of industry to intermediate goods especially imported ones and incomplete exchange rate pass through to import prices) and thereby give rise to the reported conflicting results.

By combining a CES-type production function incorporating imported and domestically produced intermediate goods with incomplete exchange rate pass through in import prices, we have contributed to this literature by developing a hybrid NKPC formulation that is *novel* in the literature. The *incomplete pass through* assumption allows us to model *import pricing* decisions and thus not only adds richer dynamics to our model, but also reflects an empirical regularity for the Turkish economy. To our knowledge there is no study that models import pricing decisions for the Turkish economy. Also, in the literature, the production side of the Turkish economy is modeled using a Cobb-Douglas production technology in which labor is used as the only factor of production. However, the Turkish input-output tables show that intermediate inputs constitute a large fraction of the total national output. Thus, the generalized CES-type of production function employed to model the domestic output structure clearly distinguishes our study from the other Turkish NKPC studies.

The characteristics of the short-run inflation dynamics in Turkey is analyzed within the context of this alternative NKPC specification by estimating the model's highly nonlinear structural parameters that capture price-setting behavior in Turkey. These parameters are the degree of *price stickiness*[1] (i.e. average time over which a price is fixed) and the degree of *backwardness*[2] in price setting (i.e. the degree of *intrinsic inflation inertia*). By identifying these parameters we could answer questions like[3]: What percent of all Turkish firms change their prices every quarter? Overall, prices are constant for an average of how many quarters or months in Turkey? What percent of all firms follow a backward looking rule of thumb behaviour (indexation) in setting their prices in Turkey? Compared to the other euro area countries, is the price duration or the degree of backward looking behavior in price setting in Turkey above or below average?

Moreover, the NKPC model developed is used to assess the relative contribution of *past inflation* and *inflation expectations* in forming the inflation

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[1] This parameter is denoted by θ in the model, which is explained briefly in Chapter III.

[2] This parameter is denoted by ω in the model, which is explained briefly in Chapter III.

[3] The first three questions asked here will be answered referring to the parameters θ, $1/(1-\theta)$ and ω, respectively. The model and these parameters are explained briefly in Chapter III.

process in Turkey. We believe that analyzing the relative importance of backward versus forward looking price setting behavior is important from a policy point of view because the output costs of a rapid disinflation would tend to be higher with backward-looking behavior[4].

Using the NKPC specification proposed for Turkey as a tool, our secondary aim is to conduct policy analysis. Based on the NKPC estimates obtained, we have examined the effects of the *inflation targeting policy* introduced after the 2000-01 crisis on the persistence of inflation (inflation inertia) and analyzed whether expected inflation now has a larger effect on current inflation. A central bank facing inflation that is largely determined by *past inflation* (*backward looking*) will probably have to tighten monetary policy more to achieve an inflation target. A *successful* inflation targeting framework should enhance the credibility of monetary policy and make current inflation a function largely of *expected inflation* (i.e., forward looking component). This makes monetary policy more *effective*, requiring less tightening to achieve a given inflation target.

Our results have provided empirical support for the open economy NKPC model developed for the Turkish economy. The estimates of the structural and reduced form parameters obtained from the NKPC model were in the theoretically plausible range and statistically significant. The NKPC model developed was found quite successful in terms of its ability to explain the observed inflation dynamics in Turkey. Moreover, the NKPC model was supported by the data when estimated by the continuous updating Generalized Method of Moments (CU-GMM) estimator, was robust to GMM estimation of the closed form and outperformed a closed economy model and an open economy model without imported intermediate inputs. Thus, the key features introduced to the NKPC model did significantly improve the validity of our results. The results of the policy analysis suggested that, for the period under

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[4] Backward looking and forward looking components of inflation are denoted by γ_b and γ_f, respectively. See Chapter III for further details.

study, the inflation targeting framework applied in Turkey was successful in terms of decreasing indexation and inflation inertia in Turkey

Chapter II surveys the literature on the NKPC by discussing i) the historical evolution of the Phillips curve towards the NKPC, ii) the closed and open economy NKPC models from both a theoretical and an empirical perspective, and iii) the key features of the NKPC model developed for the Turkish economy. Chapter III describes the environment of the NKPC model, explains the optimizing behaviors of the representative agents in the economy, and derives the CPI based NKPC equation developed for Turkey and interprets its determinants. Chapter IV presents the data used in the study and its sources along with the results of the estimates of the NKPC model. It discusses the econometric methodology used in the study, examines the fit of the curve and reports the results of the various robustness analyses performed on the NKPC. Finally, it investigates the stability of the NKPC over the post 1989 period and discusses whether over the recent past the dynamics of inflation have changed with the adoption of the implicit inflation targeting regime in 2002. Chapter V is reserved for concluding remarks.

CHAPTER II

THEORETICAL AND EMPIRICAL LITERATURE ON THE NEW KEYNESIAN PHILLIPS CURVE

Phillips curve has always been one of the most important and controversial relations in macroeconomics. It has undergone recurrent revisions as macroeconomics has evolved with the introduction of rational expectations, intertemporal optimization and various rigidities. Still over the last decade it has been challenged by the so-called New Keynesian Phillips Curve (NKPC). We discuss this historical evolution of the Phillips curve towards the NKPC in section II.A. The New Keynesian Phillips Curve (NKPC) can be derived using closed economy or open economy models. We discuss these models from both a theoretical and an empirical perspective in section II.B. There is an ongoing debate on the empirical validity and appropriate specification of both the closed and open NKPC models. This debate which is reflected in part in section II.B does suggest that diverse modeling approaches are still confronted and they give rise to different policy implications. A few NKPC studies that are applied to Turkish data also provide mixed evidence on the validity of this curve for the Turkish economy and section II.C is reserved for the survey of these studies. We evaluate the Turkish literature from mainly a theoretical point of view by contrasting the modeling strategies used in these studies with our approach. Thereby, the mixed empirical results reported regarding the applicability of the NKPC to the Turkish economy is attributed to these diverse modeling approaches. Finally, in section II.D we conclude with a brief summary of the main findings and a discussion on what approach seems most promising of being able to solve the problems that the NKPC has in fitting the empirical facts and ensuring a successful adaptation to the Turkish economy. We highlight the lessons derived from the literature and relate them to the key modeling features of the Turkish NKPC formulation. The NKPC models employed in the Turkish studies do not take one or more of these features into consideration, thereby causing the conflicting empirical results.

II.A THE HISTORICAL EVOLUTION TOWARDS THE NKPC

The Phillips curve has been vital for over 50 years in macroeconomic models. The curve entered the economics literature in 1958, when A. W. Phillips documented a regular negative relationship between the rate of unemployment and the rate of change in money wages in the United Kingdom since 1861. However, it was with the Samuelson and Solow 1960 article that the term *Phillips Curve* entered the field of macroeconomics. Samuelson and Solow showed that the same empirical regularity between unemployment and inflation (wages or prices) also held for the United States data and explored the *policy applications* of this stable negative relationship. They interpreted the Phillips curve as representing a stable policy *tradeoff* between unemployment and the inflation rate. For instance, policy makers could have low unemployment *permanently* as long as they could tolerate high inflation.

As argued in Mankiw (2006), starting with the work of Samuelson and Solow (1960), some sort of a Phillips curve relationship was included as an equation in the Keynesian models although no such reference was made by Keynes himself. This model which merged key elements of the Keynesian approach and some classical elements like the long run Phillips curve was referred to as the *neoclassical synthesis* (Galí, 2000; Gordon, 1990) or the *neoclassical-Keynesian synthesis* (Mankiw, 2006). In the late 1960s Milton Friedman and Edmund Phelps rejected this synthesis and initiated a new wave in macroeconomics called as the *new classical economics.*

Friedman and Phelps strongly disagreed on the ability of the policy makers to exploit the Phillips curve tradeoff, especially in the long-run[5]. They argued that this tradeoff would actually disappear once policy makers actually tried to use it because that would sooner or later change the way the *expectations* were formed, thereby causing the unemployment rate to stabilize eventually at a certain rate, which they have called the *natural rate of unemployment*. Friedman (1968) and Phelps (1967, 1968) have introduced the concept of the natural rate of unemployment to the Phillips curve and their attack on the Phillips curve took the form of the *natural rate hypothesis.*

The natural rate hypothesis argues that in the long-run the policy makers cannot choose an unemployment rate other than the natural rate of unemployment. The natural rate of unemployment is the unemployment rate that makes the actual inflation rate equal to the expected inflation and it is the one that is required to keep the inflation rate constant. These ideas resulted in the distinction between the *long run Phillips curve* that is vertical at the natural rate of unemployment where inflation equals expected inflation and the negatively sloped *short run Phillips curve* where inflation and its expectation are allowed to deviate. The Phillips curve that incorporates these ideas came to be called the *expectations augmented Phillips curve.*

The expectations augmented Phillips curve postulates a stable and negative relationship between *unanticipated inflation* (the difference between the actual and expected inflation rates) and *cyclical unemployment* (the difference between the actual and natural unemployment rates) instead of a stable and negative relationship between *inflation* and *unemployment* (Abel, Bernanke and Croushore, 2008, p. 447; Blanchard, 2009, p. 193). According to the expectations augmented Phillips curve, unemployment will fall below the natural rate only when inflation is *unanticipated* (i.e. when actual and expected

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[5] Samuelson and Solow (1960) have warned in their article that they have conducted their analysis on the Phillips curve for the short run and that the shape of the Phillips curve may change in the long run. They have argued that if policy changes in the next few years, this might definitely cause the Phillips curve to shift. However, as argued by Mankiw (2006) all these warnings were not taken into account by the later literature.

inflation differ). Since these effects can last as long as the expectation errors last and that cannot be very long, at the end, in the *long run money is neutral*.

The models developed by Friedman and Phelps assumed *imperfect information* about changes in prices and continual *market clearance*. Later, in 1970s, Robert Lucas took the models developed by Friedman and Phelps one step further by introducing the idea of *rational expectations*. This marked the second set of contributions to the new classical macroeconomics. The rational expectations approach assumes that people use all relevant information in forming forecasts of economic variables. However, this does not mean that these forecasts are always accurate, but rather that people with rational expectations do not consistently make the same forecasting errors.

Lucas (1972, 1973) is the *intellectual founder* of the *rational expectations equilibrium approach to macroeconomics*, which seeks to explain all macroeconomic phenomena starting from microeconomic foundations and by assuming that markets clear and expectations are rational[6]. The rational expectations and market clearance assumptions employed by Lucas lead to the introduction of the *policy ineffectiveness* proposition[7]. This proposition asserts that *anticipated* monetary policy cannot change real gross domestic product (GDP) in a regular or predictable way. Thus, the central banks wanting to use monetary policy to change the behavior of output systematically should conduct *unanticipated* changes in money stock (i.e. a money surprise) in a systematic way. However, since public has rational expectations, the central banks wouldn't be able to surprise the public systematically and thus monetary policy could not be used to stabilize output. Therefore, as in the Friedman-Phelps analysis, *money is neutral* in the *long run*. In general, a Phillips curve

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[6] As argued in (Abel et al., 2008, p. 447 and Gordon, 2009, p. 557) Robert Lucas did not discover the idea of rational expectations but rather he is the one who applied this principle to macroeconomics.

[7] As argued in Gordon (2008) although the policy ineffectiveness proposition is generally attributed to Lucas, it was formally developed by Sargent and Wallace (1975).

that has microeconomic foundations under rational expectations is called as the *New Classical Phillips curve*[8].

The rational expectations assumption had another very important implication: the *Lucas critique*. Generally, to predict the effects of a new policy rule, policy makers assume that the historical relationships between macroeconomic variables will continue to hold also after the new policies are in place. Lucas (1976) disagreed with this assumption and argued that because new policies affect economic behavior and thus expectations, the underlying relationship between variables may eventually change as the policy makers try to use it. Lucas critique was one important theoretical motivation for an intertemporal approach. The Lucas critique claimed that the failure of the traditional structural macroeconomic models was caused by regime shifts which resulted from policy changes and shifts in expectations. According to the Lucas critique, policy experiments should be done on the basis of *intertemporal general equilibrium optimization models* that have explicit microeconomic foundations. Lucas's insistence on grounding policy analysis in the actual forward looking decision rules of economic agents suggested that macroeconomic models might yield more reliable policy conclusions if demand and supply functions were derived from the optimization problems of households and firms rather than specified to match ad hoc specifications. Although the Lucas critique targets all macroeconometric models of 1970s, it is usually formulated as a critique of the Phillips curve relation. The clear stable negative relation between inflation and unemployment evident in the data in the 1960s disappeared in the 1970s as the policy makers tried to exploit the negative tradeoff by designing polices based on it.

The concept of a stable unemployment inflation tradeoff was challenged not only on theoretical grounds in the 1970s with the works of Friedman-Phelps and Lucas-Sargent, but also on empirical grounds when the negative relation

[8] More formally, the New Classical Phillips curve is represented by $\pi_t = E_{t-1}\pi_t + \gamma x_t$ where $E_{t-1}\pi_t$ is the expected inflation in period t which was forecasted in period $t-1$ and x_t refers to real economic activity that is measured by the output gap.

between unemployment and inflation so visible in the 1960s broke down in the 1970s (Gordon, 2008). By the mid 1970s the United States was experiencing *stagflation*, a term used to express the notion of simultaneously rising unemployment and inflation. This positive correlation between inflation and unemployment was the opposite of what the Phillips Curve had predicted so far. One important source of this empirical failure was the adverse supply shocks like the oil price shocks that hit the US economy twice in the 1970s. The other and perhaps more important source was that wage setters changed the way they formed their expectations as inflation became more high and persistent in the 1970s, so that Friedman and Phelps were indeed right (Blanchard, 2009, pp. 189-190, Abel et al., 2008, p. 454).

Owing to the empirical failures and theoretical shortcomings explained above, in the 1970s and continuing in the 1980s, the Phillips curve was nearly declared as dead. The failure of the Phillips curve brought Keynesian economics under serious attacks. Lucas and Sargent published an article in 1978 saying that,

> The task now facing contemporary students of the business cycle is to sort through the wreckage ... of that remarkable intellectual event called the Keynesian Revolution … existing Keynesian macroeconometric models cannot provide reliable guidance in the formulation of monetary, fiscal, or other types of policy…there is no hope that minor or even major modification of these models will lead to significant improvement in their reliability.

However, in the meantime, the resurrection of Keynesian economics and the Phillips curve began with birth of the *new Keynesian economics*. Thus, since the 1970s, macroeconomics has been divided between two schools of thought: the new classicals discussed above and the new Keynesians. Gordon (2008) argues that the New Keynesian paradigm first developed in the late 1970s by the works of Fisher (1977) and Taylor (1980)[9]. As opposed to the new

[9] However, Mankiw (2006) argues that the first studies that could be associated with the New Keynesian paradigm were Barro and Grossman (1971) and Malinvaud (1977).

classicals, the new Keynesians intended to remedy the weaknesses of the earlier neoclassical synthesis. The new Keynesians have agreed with Keynes's view that prices and wages do not change fast enough to always clear markets as thought by the classical school and have tried to understand the microeconomic justifications behind this slow adjustment. As discussed in Mankiw and Romer (1991a, pp. 2-3), microeconomic imperfections such as imperfect competition and rigidity in relative prices are central elements of the new Keynesian theory in trying to explain the stickiness of prices. The new Keynesian economics argues that variations in nominal variables like the ones in money supply affect the variations in real variables (i.e. classical dichotomy does not hold) and attributes this failure to sticky prices (i.e. nominal rigidities)[10].

As the 1980s and 1990s were witnessing the growing tension between the new Keynesians and classicals, a new synthesis that combined the strengths of the two was emerging to explain the economic fluctuations (Mankiw, 2006). Goodfriend and King (1997) have given this new consensus the name *new neoclassical synthesis*. Goodfriend (2002, p 176) argues that they have used this name "recalling Paul Samuelson's designation for the original attempt to synthesize classical and Keynesian economics in the 1950s".

The new neoclassical synthesis has incorporated the Keynesian elements of *nominal rigidities* and *imperfect competition* into an *intertemporal optimizing dynamic general equilibrium* model with rational expectations that was largely associated with the last generation of new classical economics - the *real business cycle (RBC) paradigm*[11]. In the late 1970s the RBC theory has emerged with the works of Kydland and Prescott (1982), Long and Plosser (1983) and King and Plosser (1984) as the third strand of the new classical

[10] For a detailed discussion on new Keynesian economics see Mankiw and Romer (1991a, 1991b).

[11] See Goodfriend and King (1997) and Clarida, Galí and Gertler (1999) for a comprehensive survey of this literature. The most detailed discussion on the new neoclassical synthesis can be found in Woodford (2003).

economics. The RBC models left aside the assumption of imperfect information employed by Lucas and Friedman but retained their assumptions of continuous market clearance and perfect markets. The RBC models have dealt with the real side of the economy and explained the business cycles as being caused by productivity or supply shocks with money playing no role. An important contribution of the RBC theory was its *methodology* in using *dynamic stochastic general equilibrium models* with explicit microeconomic foundations and doing simulations on the calibrated model to replicate the real data. As argued by Goodfriend (2002) the name new *neoclassical* synthesis was given to these new generation models especially to emphasize the fact that these had the RBC model, initiated by the third wave of the new *classical* economics, at its core.

The presence of *nominal rigidities* in the new neoclassical synthesis models causes alternative monetary settings to have *nontrivial* effects on real variables. Therefore monetary policy has become an important source of economic fluctuations and a tool for stabilization in this new paradigm. This lies in stark contradiction to the RBC models where monetary policy plays no role in stabilizing the fluctuations in the real activity. Therefore, in modern macroeconomics literature, the new neoclassical synthesis models have become the main analytical framework for analyzing the effects of monetary policy in a closed economy structure. These models are used to analyze the connection between money, inflation, and the business cycle, and to assess the desirability of alternative monetary policies, and for a direct exploration of the data. They are theoretically consistent, have explicit microeconomic foundations, are able to model risk and uncertainty, and provide a rigorous analytical groundwork for credible welfare and policy analysis.

While Roberts (1995) shows that different *new Keynesian models* of Calvo (1983), Taylor (1980) and Rotemberg (1982) lead to a common formulation that he has termed as the *new Keynesian Phillips curve (NKPC)*; Mankiw (2006) and Gordon (2008) argue that the NKPC should be clearly distinguished from these early new Keynesian studies. Mankiw (2006) has called the new generation models that result in the NKPC equation as the *new neoclassical synthesis* models. We will follow Mankiw (2006) and call the equation describing the *supply* block of the new neoclassical synthesis model as the NKPC. The *nature of inflation dynamics* is arguably the most distinctive feature of the new neoclassical synthesis paradigm and it is captured by the so-called New Keynesian Phillips curve (NKPC). Basically, the NKPC serves to estimate the model's structural parameters that capture *price setting behavior* in an economy.

II.B CLOSED AND OPEN ECONOMY NKPC MODELS

As argued in Gordon (2008), the Phillips curve has mainly embraced an American perspective since the work of Samuelson and Solow (1960). Gordon (2008) attributes this to the dominance of the literature by Americans and to the empirical studies generally investigating its applicability to the American economy. For the same reasons the early literature on the NKPC has also adopted an American perspective. Since the U.S. is virtually considered as a closed economy, the most influential papers of the early NKPC literature has commonly used closed economy models[12]. Still in the literature when one refers to the so called NKPC, a single basic formulation comes into mind and that is the standard *closed* economy NKPC specification that will be presented in subsection II.B.1.

In this subsection we will discuss the features of this closed economy NKPC specification that are new relative to the traditional Phillips curve discussed in the first section[13]. Also the existing empirical evidence will be surveyed in the

[12] See, among others, Fuhrer and Moore (1995), Fuhrer (1997), Roberts (1997), Galí and Gertler (1999), Galí et al. (2001) and Sbordone (2002).

[13] We will refer to any *backward looking* Phillips curve that relates inflation to some *cyclical indicator* (like output gap or unemployment rate) and *lagged values of inflation* as the traditional Phillips curve. A commonly used empirical specification of this curve is given by

context of the closed economy NKPC model and the revisions made to improve its empirical fit will be discussed. Despite these revisions, the literature has still not arrived at a consensus on the merits of the closed economy NKPC model and the disagreements relating to the estimation methods, measurement of the variables and policy applications will all be discussed in this section.

More recently, Holmberg (2006), Batini et al. (2005), Barkbu and Batini (2005), Banerjee and Batini (2004), Balakrishnan and Lòpez-Salido (2002), and Galí and Lòpez-Salido (2001) have highlighted the importance of introducing *open* economy aspects to the basic closed economy specification of the NKPC. These authors agree that external influences on inflation need to be taken into account to improve the validity of the results. Thus, subsection II.B.2 discusses the open economy NKPC models from both a theoretical and an empirical point of view.

We agree that extending the NKPC to include open economy factors is important since new channels that affect inflation dynamics arise with the opening of the economy to the rest of the world and these should be considered especially if one is to model inflation dynamics of a small open economy like Turkey. First and foremost, the effect of *exchange rate and terms of trade* shocks on the price setting process and therefore on inflation must be taken into account. Second, firms' marginal costs and price setting decisions are influenced by the *imported goods* both at final and intermediate good levels. However, the introduction of these open economy factors greatly complicates the theoretical and empirical foundations of the open economy NKPC models. First *exchange rate pass through* should be appropriately modeled and second the *marginal cost* should be correctly measured with the introduction of imported intermediate goods. Therefore, there is a vigorous on-going debate on

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$\pi_t = \sum_{i=1}^{h} \varphi_i \pi_{t-i} + \lambda x_{t-1} + \varepsilon_t$ where x_t denotes the cyclical indicator used (Galí et al., 2001). Some applications add more lagged values of the cyclical indicator to this specification. Note that our definition also includes the New Classical Phillips curve discussed in section II.A.

the appropriate specification of the open economy NKPC model. This debate which is reflected in part in subsection II.B.2 does suggest that a consensus is not yet reached. Diverse modeling approaches are still confronted and they give rise to different policy implications.

II.B.1 Closed Economy New Keynesian Phillips Curve Models

The *standard* formulation of the NKPC describes the inflation process within a dynamic general equilibrium framework where monopolistically competitive firms face constraints on price changes. In most of the literature a *rational expectations staggered price setting model* of Calvo (1983) is assumed to simplify the aggregation problem where each firm has a probability *(1-θ)* of being able to reset its price in any given period[14]. Then, optimization on behalf of firms subject to this Calvo pricing constraint leads to the following *pure forward looking* version of the NKPC[15]

$$\pi_t = \lambda mc_t + \beta E_t \left\{ \pi_{t+1} \right\} \tag{2.1}$$

where π_t denotes the inflation rate at time t, mc_t represents the firm's real marginal cost (measured as log deviation in period t from its steady state value) and $0<\beta<1$ is the subjective discount factor[16,17]. $E_t \left\{ \pi_{t+1} \right\}$ is the *rational*

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[14] See Chapter III for details.

[15] Roberts (1995) have showed that, besides the Calvo (1983) model given here, the staggered contracts model of Taylor (1980) and the quadratic price adjustment cost model of Rotemberg (1982) also lead to the common formulation given in equation (2.1).

[16] A detailed derivation of this equation can be found in Woodford (2003, pp. 187-188).

[17] Several studies introduce an error term ε_t into the final econometric specification of this baseline NKPC by first solving the model without the error term and then estimating the resulting NKPC equation with an error term tacked onto it. The error term is intended to capture (unexplained) transitory deviations from the theory (Fanelli, 2008), structural misspecifications of the model or approximation errors induced by the linearization (Kurmann, 2004), measurement error or shocks to desired markup (Galí et al. 2005), and errors due to non-linearities in the theory and/or data mismeasurement (Kurmann, 2007). The NKPC specified with a stochastic error term in this way is termed by some studies as the *inexact version* of the NKPC. See Kurmann (2007), Fanelli (2008), Boug, Cappelen and Swensen (2010) for details.

expectation of π_{t+1} at *t* that is conditional on all the information available at time *t* implied by the model, Ω_t.

In a Calvo model with each firm being able to adjust its price with a fixed probability of *(1-θ)* in every period, the reduced from parameter *λ* is a nonlinear function of the subjective discount factor (*β*) and the parameter of price rigidity (*θ*)[18,19]. The lower is the parameter of price rigidity *θ,* the higher is the response of inflation to changes in marginal cost (i.e. *λ* is decreasing in *θ*). Since the NKPC is derived from a theoretical model that is based on *microeconomic* principles, its reduced form parameters are directly linked to the behavior of agents and so are functions of the structural parameters of the model.

According to equation (2.1) current inflation is a function of expected *future inflation* and current real marginal costs, which is a measure of the real economic activity. In the *traditional Phillips curve*, inflation is also a function of the real economic activity, but the striking difference is the *forward looking* nature of inflation emphasized by equation (2.1). This difference stems from the expected future inflation term appearing in equation (2.1) so that when (2.1) is iterated forward, one can obtain,

$$\pi_t = \lambda \sum_{k=0}^{\infty} \beta^k E_t \left\{ mc_{t+k} \right\} \tag{2.2}$$

In contrast to what the traditional Phillips curve literature argues, equation (2.2) clearly shows that *past inflation* is *not* a relevant factor in determining current inflation. Current inflation is just equal to a discounted stream of expected

[18] See Chapter III for details on the Calvo price setting rule.

[19] Equation (2.1) corresponds to the basic formulation where real marginal costs are assumed to be constant and identical across firms. If one assumes increasing real marginal costs that vary across firms then the coefficient of marginal cost (*λ* here*)* will also be a function of the elasticity of the firm's real marginal cost with respect to its output and elasticity of the firm's demand with respect to its price. See Gagnon and Khan (2005) for alternative derivations based on different production technologies.

future marginal costs. Therefore, equation (2.1) is called the *pure forward looking* specification of the NKPC. The NKPC in this form implies *no intrinsic inflation inertia*[20]. This feature is a consequence of the fact that firms facing constraints on the frequency of price changes are aware that a price once set may remain for many periods so that they set current prices in anticipation of future demand and cost conditions. Since aggregate price level in any period is determined by current pricing decisions, inflation is forward looking. This *forward looking* nature of inflation dynamics is the most crucial feature of the NKPC literature.

Equation (2.1) makes it clear that the theory underlying the NKPC relates inflation to *real marginal costs*. Inflation is the result of the aggregate pricing decisions in the economy. Thus, in an economy populated by monopolistically competitive producers whose pricing decision are driven by their real marginal costs, the correct measure to use that affects inflation is the real marginal cost. The closed economy applications of the NKPC have commonly used an *output gap* variable (i.e. detrended gross domestic product) to measure the real marginal cost. With certain restrictions on technology and labor market structure, real marginal costs can be proved to move *proportionately* with the *output gap* and therefore equation (2.1) can be reformulated as follows[21]:

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa y_t \tag{2.3}$$

where y_t denotes the output gap (again expressed as percentage deviations from its steady state value). When this equation is iterated forward the following equation is obtained:

[20] Intrinsic inflation inertia is defined by Rudd and Whelan (2007) as the structural dependence of inflation on its own lagged values. The details of how it is represented within the NKPC framework will be covered in Chapter III.

[21] See Galí and Gerter (1999) and Galí et al. (2001) and the references therein.

$$\pi_t = \kappa \sum_{k=0}^{\infty} \beta^k E_t \left\{ y_{t+k} \right\} \tag{2.4}$$

Despite the strengths that the NKPC enjoys on the theoretical side, the pure forward looking version given in (2.3) has been criticized for producing implausible results regarding inflation dynamics. First, in contrast to what equation (2.2) predicts inflation displays a considerable degree of inertia (Christiano, Eichenbaum and Evans, 2005; Fuhrer and Moore, 1995). Second, equation (2.4) implies a positive correlation between current inflation and future output and therefore leads to the conclusion that inflation *leads* output. However, the opposite is found when business cycle data is analyzed (Fuhrer and Moore, 1995; Galí and Gertler, 1999). Third, it follows from (2.4) that inflation can be reduced immediately *without* any output loss if a central bank can credibly commit itself to a zero path of future output gaps. However, as discussed in Galí and Gertler (1999), Fuhrer and Moore (1995), and Ball (1994) disinflations induce large output losses. Fourth, equation (2.3) implies that the response of inflation to contractionary or expansionary monetary policy involves jumps, but the data shows that inflation responds to monetary policy shocks in a hump shaped fashion. (Ball, 1994; Christiano et al., 2005).

These empirical shortcomings have led the literature to develop a NKPC model that nests the pure forward looking NKPC and the backward looking traditional Phillips curve into a *hybrid* form where current inflation is also a function of *past inflation*. Galí and Gertler (1999) and Galí et al. (2001) introduce past inflation to the NKPC model by assuming that, within the group of Calvo price setter firms some follow a *backward looking rule of thumb* updating their prices with past inflation while the rest sets it optimally. The existence of *backward looking firms* introduces *intrinsic inflation inertia* to the model. This formulation leads to the following hybrid NKPC:

$$\pi_t = \gamma mc_t + \gamma_f E_t \left\{ \pi_{t+1} \right\} + \gamma_b \pi_{t-1} \tag{2.5}$$

In this hybrid formulation of the NKPC, current inflation is again a function of the current real marginal cost, but this time it has not only a *forward* looking component measured by γ_f, but also a *backward* looking component represented by γ_b. With ω denoting the fraction of firms setting their prices according to the backward looking rule of thumb, the reduced from parameters γ, γ_b and γ_f are nonlinear functions of the structural parameters θ (denoting the parameter of price rigidity), ω (indicating the degree of intrinsic inflation inertia) and β (representing the subjective discount factor)[22, 23].

More recently, Christiano et al. (2005), Eichenbaum and Fisher (2003), Tillmann (2009) and Giannoni and Woodford (2003) have used *price indexation rules* to motivate the presence of the lagged inflation term. In these models the θ fraction of firms that cannot reoptimize their price, index it to last period's inflation rate. The hybrid NKPC specification resulting from these models is the same as the one given in equation (2.5). The only difference lies in the solution of reduced form parameters in terms of the structural parameters; γ_b and γ_f are in this case nonlinear functions of only the subjective discount factor β and γ is a function of both β and the price rigidity parameter θ.

Interestingly enough, the empirical applications of the hybrid NKPC have also met with failure until the *seminal* works of Galí and Gertler (1999) and Galí et al. (2001). As argued in Galí and Gertler (1999), when output gap is used as a proxy for marginal cost and the hybrid NKPC given in equation (2.5) is estimated with quarterly data, the coefficient of output gap is found insignificant[24]. Galí and Gertler (1999) and Galí (2002) attribute this failure to two basic things. First is the observed poor relationship between the output

[22] See Chapter III for details on the analytical formulation of backward looking rule of thumb.

[23] See footnote 15. In equation (2.5) the parameter γ will also be a function of the elasticity of the firm's real marginal cost with respect to its output and elasticity of the firm's demand with respect to its price.

[24] See Galí and Gertler (1999) and the references therein for critiques of these early studies.

gap and real marginal cost. Second is the inability of the existing literature to correctly measure the output gap variable and the incorrect usage of the detrended GDP as a proxy for the output gap.

This *labor share versus output gap debate* has caused too much controversy in the literature and caused one strand of the NKPC literature to concentrate on whether *labor share* or *output gap* should be used as a proxy for marginal cost. The results of Sbordone (2002) and Galí and Gertler (1999) applied to U.S. data and Galí et al. (2001) to U.S. and Euro area data have revealed empirical support for the labor share based NKPC. Applying several specification tests, Jondeau and Le Bihan (2005) have found empirical support for this labor share based hybrid NKPC model when applied to the U.S. data. However, for the Euro area, the authors have preferred an output gap based specification with three leads and lags of inflation. Similarly, Neiss and Nelson (2005) have argued that if theory consistent estimates of the output gap are used, the coefficient of the output gap is estimated significantly with correct sign for the U.S., the U.K. and Australia. Also in Paloviita (2006) output gap turns out to be at least as good as a unit labor cost proxy for real marginal cost in the Euro area using observed measures of inflation expectations. By the same token Zhang, Osborn and Kim (2009) using direct measures of inflation expectations and identification robust tests have showed that for the U.S., output gap is a significant driving variable of inflation if serial correlation is taken into account using an extended NKPC model. Henzel and Wollmershäuser (2008) also using direct measures of inflation expectations indicate that, while for some countries (the Euro zone, France, Germany) the labor share is the driving variable of inflation, for others (Italy, the UK, the US) the output gap is the appropriate measure to be used. On the other hand, Rudd and Whelan (2007, 2005b), using a vector autoregressive (VAR) based method to evaluate the empirical fit of the NKPC have argued that neither a labor share nor an output gap proxy causes the NKPC model to explain the U.S. inflation dynamics well.

Assuming that ε_t is i.i.d., Galí and Gertler (1999) and Galí et al. (2001) have estimated equations (2.1) and (2.5) by *Generalized Method of Moments (GMM)*. Another strand of the NKPC literature has criticized the *estimation methodology* used in these studies. Rudd and Whelan (2005a) and Lindé (2005) have argued that some of the empirical findings of Galí and Gertler (1999) and Galí et al. (2001) are the result of the specification bias associated with the GMM procedure. Rudd and Whelan (2005a, 2006) have alternatively suggested estimating the forward closed form solution directly using GMM and Lindé (2005) has employed nonlinear instrumental variables but proposed the use of the full information maximum likelihood (FIML) estimation method. However, Galí et al. (2005) have argued that their estimates are robust to a variety of estimation techniques including the GMM estimation of the closed form solution and the nonlinear instrumental variables.

Other authors have questioned the GMM procedure due to the fact that it is not robust to the *weak instrument* problems[25]. Ma (2002) has evaluated the empirical fit of Galí and Gertler's (1999) hybrid NKPC specification using the weak identification test statistics developed by Stock and Wright (2000) and obtained unreasonably large confidence sets and concluded that the parameters of the hybrid model are weakly identified. Also Mavroeidis (2004, 2005) have showed that the pure and hybrid NKPC specifications of Galí and Gertler (1999) are weakly identified using a measure of strength of identification called as the concentration parameter. More recently, the weak identification of the hybrid NKPC specification has been corroborated by the studies of Kleibergen and Mavroeidis (2009) using a variety of identification robust tests, Martins and Gabriel (2009) employing an integrated inference approach based on

[25] There are two requirements that the instruments must satisfy: instrument *exogeneity* and instrument *relevance*. Instrument *exogeneity* refers to the condition that the instruments must satisfy the moment conditions. If this requirement is violated then the GMM estimator loses its asymptotic properties starting with consistency. The second condition, instrument *relevance*, refers to the case that the instruments be correlated with the variables they replace in the moment conditions. When instruments are *weakly correlated* with the endogenous variables they replace, the sampling distributions of GMM statistics are in general non-normal and standard GMM estimates, hypothesis tests and confidence intervals are unreliable. The weak instrument problem is well documented in the papers by Stock, Wright and Yogo (2002), Kleibergen (2002), Dufour and Jasiak (2001), Dufour (2003), Dufour et al. (2006).

Generalized Empirical Likelihood (GEL) methods and Nason and Smith (2008) which study the identification of the NKPC within a three equation New Keynesian model. Mavroeidis (2005) using Monte Carlo experiments has further demonstrated that when the NKPC model is weakly identified, the GMM estimation would tend to give dominant forward looking behavior even in the case that the NKPC is purely forward looking. Dufour et al. (2006) using Anderson and Rubin (1949) (AR) test discussed and extended by Dufour and Jasiak (2001), Dufour (2003) and Dufour et al (2006) and Kleibergen test developed by Kleibergen (2002), have argued that the hybrid NKPC specification of Galí and Gertler (1999) fails to give a good description of the inflationary process for Canada whether one uses survey data for inflation expectations or impose the rational expectations assumption as done in Galí and Gertler (1999). However, for the U.S the authors find some support for Galí and Gertler's (1999) hybrid NKPC specification with rational expectations. On the other hand, Nason and Smith (2008) also using the AR test have reject the hybrid NKPC model for the U.S. by applying the LM test of Guggenberger and Smith (2008), which is robust to weak instruments and that suffers no power loss as does the AR test when over-identification arises. On the other hand, Kleibergen and Mavroeidis (2009) obtain very wide confidence intervals for the NKPC parameter estimates and conclude that they are consistent with both the pure and hybrid NKPC model for characterizing the U.S. inflation dynamics. Nason and Smith (2008) have also rejected the hybrid NKPC model for U.K. and Canada.

Galí and Gertler (1999) and Galí et al. (2001) have evaluated the goodness of fit of their model by constructing a *fundamental inflation* series. The so called fundamental inflation is derived as the stable forward form solution of the second order NKPC difference equation and expected terms are forecasted with a vector autoregressive (VAR) process. Galí and Gertler (1999) and Galí et al. (2001) have find that the fundamental inflation series thereby obtained explains the actual inflation series of the U.S. economy quite well. Also Sbordone (2002) has corroborated the findings of Galí and Gertler (1999) for the U.S.

economy by deriving the fundamental inflation series[26]. Furthermore, Kurmann (2005) has investigated and calculated the estimation uncertainty surrounding the fundamental inflation series using a variety of methods and concluded that no one can say with any degree of confidence whether the Calvo model explains U.S. inflation very poorly or very well. Following Kurmann (2005) and using bootstrapped confidence bands to quantify the estimation uncertainty, Tillmann (2009) have corroborated Kurmann's (2005) results for the Euro area. In addition, Carriero (2008) by testing the restrictions that the forward form solution of the NKPC model implies on the VAR have showed that the hybrid specifications of Galí and Gertler (1999) and Galí et al. (2001) fail to exist as a combination of structural parameters consistent with the U.S. data

Recently, Fanelli and Polomba (in press), Koronek, Radchenko and Swanson (2010), Boug et al. (2010), Fanelli (2008) and Kurmann (2007) have further re-evaluated the empirical validity of the findings in Galí and Gertler (1999) and Galí et al. (2001) by using *likelihood* based methods. This new strand of the literature, instead of estimating the NKPC with GMM or FIML, have forecasted the expected variables with a VAR process, derived the cross equation restrictions that the NKPC implies on the VAR under rational expectations and then estimated the implied restricted VAR with maximum likelihood (ML). Kurmann (2007) has *reverse engineered* the cross equation restrictions as constraints on the VAR coefficients of the forcing variable of the NKPC and obtained ML estimates of the restricted VAR thereby obtained. Using this method, Kurmann (2007) has not rejected the hybrid NKPC specification of Galí and Gertler (1999) for the U.S. using the conventional likelihood ratio (LR) test. However, Fanelli (2008) by first reparametrizing the VAR in vector error correction (VEC) form to take into account the nonstationarity of the variables and then deriving the cross equation restrictions

[26] Galí and Gertler (1999) and Sbordone (2002) both use the fundamental inflation series to evaluate their models empirical fit but the methodology used in evaluation is very different in the two studies. For a discussion on the differences in the two methodologies refer to Galí and Gertler (1999).

involved, has concluded that the hybrid NKPC could not be used to represent the inflation dynamics in the Euro area. On the other hand, Fanelli and Polomba (in press) have showed that the hybrid NKPC specification of Galí et al. (2001) is rejected on Euro area data only when the LR test is compared to the standard asymptotic critical values. Once the nonstationarity of the variables are considered and a local Monte Carlo (LMC) likelihood ratio (LR) type test is computed, the European inflation dynamics is found to be represented well by the hybrid NKPC. Boug et al. (2010) has confirmed the findings of Kurmann (2007) and Fanelli (2008) that the hybrid NKPC is rejected on Euro area data but not rejected for the U.S. data. The authors have extended these studies by testing not only the hybrid but the pure forward looking form of the exact as well as the inexact NKPC model, writing the log-likelihood as a function of all the parameters involved and testing the assumption of the inexact model that the error term exhibits no autocorrelation[27]. Moreover, Koronek et al. (2010), using a slightly different methodology, have compared the empirical performance of the pure forward looking and hybrid sticky price models as well as the sticky information model of Mankiw and Reis (2002) and concluded that for 13 OECD countries the hybrid sticky price model outperformed the other two models [28]. However, when the estimate of labor share was restricted to that found in Galí and Gertler (1999), the pure forward looking sticky price model performed the best unlike the findings in Galí and Gertler (1999).

Leaving aside the arguments related with the estimation methodology, another strand of literature has investigated whether *forward or backward looking* behavior *dominates* in determining the inflation process. On the one hand, Galí and Gertler (1999), Sbordone (2002, 2005), Galí et al. (2001, 2005), Gagnon and Khan (2005), Kurmann (2007), Kleibergen and Mavroeidis (2009) and

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[27] Boug et al. (2010) call the NKPC specified without a stochastic error term as the exact version of the NKPC.

[28] The methodology followed in Koronek et al. (2010) involves augmenting the reduced from VAR by replacing the reduced form equation of inflation with different versions of NKPC equation and then estimating the NKPC by maximizing the restricted likelihood function.

Fanelli and Polomba (in press) have found that forward looking behavior dominates the backward looking behavior in determining the inflation process in the Euro area and the U.S. On the other hand, Fuhrer and Moore (1995), Fuhrer (1997), Lindè (2005), Rudd and Whelan (2005a) and Paloviita (2006) have found the opposite. Ramos-Francia and Torres (2008) using a closed economy model for Mexico have also found that the forward looking behaviour dominates. Analyzing the relative importance of backward versus forward looking price setting behavior is important from a policy point of view because the more dominant is the backward-looking behavior the higher would be the output costs of a rapid disinflation. In addition, in evaluating monetary policy different inflation behaviors may lead to very distinct results and policy recommendations. For example, while nominal income growth targeting is stabilizing in a forward looking model, the opposite is true in backward looking model (Zhang, Osborn and Kim, 2008).

The above discussion makes it clear that no consensus is yet reached regarding the empirical validity of the closed economy NKPC. There are still disagreements on the estimation and evaluation methods, proxies to be used for the real marginal cost, measurement of the output gap and policy implications of the NKPC.

II.B.2 Open Economy New Keynesian Phillips Curve Models

When one enters into the world of an open economy, compared to the closed economy case, the studies are much more limited. This branch of the NKPC literature has gained importance after the so called *New Open Economy Macroeconomics (NOEM)*. The NOEM has been pioneered by the work of Obstfeld and Rogoff (1995)[29]. These models have been used to explore many issues not addressed in the closed-economy New Keynesian framework, such as the exchange rate regime choice (Devereux, 2004; Senay and Sutherland,

[29] See Sarno (2001), Lane (2001), and Bowman and Doyle (2003) for surveys on NOEM.

2004), and exchange rate pass-through (Devereux and Engel, 2002; Smets and Wouters, 2002).

From a *theoretical* point of view, there is an ongoing debate on the appropriate microfoundation of the open economy NKPC. All the controversies surrounding the closed economy Phillips curve discussed above are still central in the open-economy setting. However, the introduction of openness complicates the modeling of the NKPC due to the introduction of imported intermediate and final goods, exchange rate dynamics and terms of trade shocks. Thus in an open economy setting, unlike the closed economy case, there is still no standard baseline model that one can refer to.

The open economy NKPC models in the literature can be decomposed into *two* broad groups. The first group introduces open economy factors into the basic closed economy model by introducing imported intermediate inputs into the production function. The *first* contributions to this group have assumed that trade took place only at one level of production: the level of intermediate goods. These studies include, among others, Bjørnstad and Nymoen (2008), Holmberg (2006); Barkbu and Batini (2005), Batini et al. (2005), Banerjee and Batini (2004), Balakrishnan and Lòpez-Salido (2002), and Galí and Lòpez-Salido (2001). On the other hand, the second wave, assumes that trade takes place at two levels of production: final and intermediate goods. These include the models by Leith and Malley (2007) and Rumler (2007).

The *second* group, ignoring the role of intermediate inputs used in production, concentrates on the interaction between exchange rate dynamics, price setting and inflation. The models in this group either assume that *law of one price* (LOOP) holds and that there is *complete exchange rate pass through* or that there are *deviations* from LOOP and exchange rate pass through is *incomplete*[30,31]. While, the models specified by Galí and Monacelli (2005),

[30] The law of one price (LOOP) argument postulates that in an efficient market identical commodities tend to have the same price regardless of where they are traded. If goods and

Khan and Zhu (2002, 2006) assume that LOOP holds, Monacelli (2005) is the first to combine a Calvo type staggered price setting structure with incomplete exchange rate pass through. In Monacelli (2005), while pass through is assumed to be incomplete for local currency import prices, the export prices are determined by the LOOP.

From an empirical point of view, the evidence on the empirical reliability of the open economy NKPC models is again rather mixed. Leith and Malley (2007) and Rumler (2007) have obtained supportive results in G7 and Euro area countries for the NKPC when open economy factors are taken into account. However, while Batini et al. (2005) argue that when open economy factors are included the NKPC specification fits the U.K. data quite well; Bardsen, Jansen and Nymoen (2004), using the same open economy NKPC model developed by Batini et al. (2005), refute this and show that the empirical relevance of this specification is very weak on U.K. data when encompassing tests are applied. Balakrishnan and Lòpez-Salido (2002) have also concluded that, although introducing open economy factors improves the fit of the NKPC, it still does not make the open economy NKPC a good representation of the data for the U.K. In addition, Bjørnstad and Nymoen (2008) have showed that the pooled estimator of the open economy NKPC in the panel of OECD

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services do follow the LOOP then the exchange rate should be so as to equate the prices of traded goods and services sold in two or more countries when measured in the same currency. For example, if the domestic price of good *z* is denoted by $P(z)$ and the foreign currency price of the same good is denoted by $P^*(z)$ then according to the LOOP, $P(z) = EP^*(z)$ where E denotes the nominal exchange rate between the two countries measured as the domestic currency price of foreign exchange.

[31] Formally exchange rate pass through is defined as the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the importing and exporting countries, as mentioned in Goldberg and Knetter (1997) and Campa and Goldberg (2002). If local currency import prices change one to one with the exchange rate then there is complete pass through. On the other hand, when the local currency import prices are totally unresponsive to the exchange rate changes then it is said that there is zero pass through. In between these two cases the exchange rate pass through is said to be incomplete. When the imported input or final goods prices change as a result of a change in the exchange rate, this is reflected in domestic prices such as producer and consumer prices. Thereby, exchange rate pass through can also be used to refer to the effect of exchange rates on the consumer and wholesale prices. As an example see Kara, Küçük Tuğer, Özlale, Tuğer, Yavuz and Yücel (2007).

countries fits the data well, but when it is evaluated against an Imperfect Competition Model (ICM) its reliability is seriously questioned[32].

On the other hand, Banerjee and Batini (2004) using the Maximum Likelihood (ML) estimation technique have concluded that the open economy NKPC represents a good characterization of the inflation process in seven open-economy industrialized countries, namely United Kingdom, Canada, France, Italy, Germany, New Zealand and Australia. However, the NKPC specification that best fits the data of these countries depend on the type of price setting structure assumed, which vary from Calvo type of staggered price contracts to Taylor or time-dependent contracts a la Dotsey, King and Wolman (1999)[33]. Barkbu and Batini (2005) have also showed that the NKPC that takes openness into account offers as a good representation of the Canadian inflation dynamics using full information maximum likelihood method proposed by Johansen and Swensen (2004). Bentolila, Dolado and Jimeno (2008) derive a NKPC that accounts for the effects of immigration and shows that with this amendment the open economy NKPC fits the Spanish data quite well.

The studies that have found empirical support for the NKPC have estimated the structural parameters of the model and/or discussed whether inflation is predominantly forward looking or backward looking. Leith and Malley (2007) have estimated the average duration of prices in the range of 8 to 26 months for the G7 economies using Generalized Method of Moments (GMM). In the sample, the average duration of prices is found to be lowest in Italy followed by the U.S and U.K. and highest in Germany while Canada, France and Japan experience an intermediate degree price stickiness of less than 1 year. The estimates of the other important structural parameter of the model, the fraction of rule of thumb price setters, was reported to vary from 7 percent to as high as 34 percent of firms in the G7 countries. It is found to be highest in Italy,

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[32] For details and the analytical foundation of the ICM model see Bjørnstad and Nymoen (2008).

[33] For details and the analytical foundation of the models involved see Banerjee and Batini (2004).

followed by Japan, U.S., Canada and Germany and lowest in U.K. and France. Rumler's (2007) GMM estimates for the Euro area countries are similar to those obtained in Leith and Malley (2007). Price rigidity is estimated to be highest in again Germany and lowest in Greece and Netherlands. The fraction of rule of thumb price setters is estimated to be highest in France and Italy and lowest in Spain, Belgium and Finland. In addition, in all the countries except Austria the forward looking behaviour in inflation dominated the backward looking behavior.

Batini et al. (2005) have also found that inflation in the U.K. is highly forward looking with a coefficient on expected future inflation equal to 0.69. The predominance of the forward looking behaviour has been corroborated by the GMM estimates of Holmberg (2006), Plessis and Burger (2006), Céspedes et al. (2005), Maturu et al. (2006), Genberg and Pauwels (2003) for Sweden, South Africa, Chile, Kenya and Hong Kong, respectively. However, Benigno and Lòpez-Salido (2006), using a model of currency area, have showed that inflation in France, Italy and Spain exhibit a predominant backward looking behavior. The degree of price rigidity is estimated to be on average 1 year for Germany, France, Italy, Spain and the Netherlands. The fraction of rule of thumb price setters is estimated to be lowest in Germany, France and the Netherlands and highest in Spain and Italy. Also, Hondroyiannis, Swamy and Tavlas (2009) have refuted the dependence of inflation process on future inflation using time varying coefficient estimation for France, Germany, U.K. and Italy.

Another strand of the open economy NKPC literature investigates the *forecasting* performance of the open economy NKPC. Rumler and Valderrama (2010) and Matheson (2008) have evaluated the forecasting performance of the open economy NKPC. Matheson (2008) has found that in Austria and New Zealand, the open economy NKPC that weights together a closed economy Phillips curve for the non-tradable sector with an open economy Phillips curve for the tradable sector, produces *better* forecasts than that of an *aggregate* open economy NKPC model that incorporates openness by including some measure of tradable sectors competitiveness. On the other hand, the aggregate NKPC specification is found to produce *poorer* forecasting performance than that obtained from a univariate autoregressive (AR) model. These results hold for forecast horizons of 6, 12 and 24 months. However, Rumler and Valderrama (2010) have showed that the aggregate open economy NKPC estimated for Austria performs *better* than a Bayesian Vector Autoregressive model (BVAR), a conventional Vector Autoregressive model (VAR) and a univariate autoregressive (AR) model for forecast horizons more than 3 months.

II.C TURKISH NKPC STUDIES

For the Turkish economy, to our knowledge, the studies that have modeled and estimated the nature of inflation dynamics using the Phillips curve literature; except the ones by Agénor and Bayraktar (2010), Çatik, Martin and Önder (2008), Celasun (2006), Yazgan and Yilmazkuday (2005) and Celasun, Gelos and Prati (2004a, 2004b) have employed *traditional Phillips curves*[34].

Agénor and Bayraktar (2010) have estimated four different forward looking Phillips curve specifications for Turkey. Two of their specifications follow from Galí and Gertler (1999). They estimate Galí and Gertler's (1999) hybrid closed economy NKPC specification and a version that extends it to include

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[34] Examples of studies that estimate traditional Phillips curves for the Turkish economy include Domaç (2004), Önder (2006, 2004), Kuştepeli (2005), Sarıkaya, Öğünç, Ece, Kara and Ozlale (2005), Öğünç and Ece (2004) and Öğünç (2006). Kuştepeli (2005) investigates the existence of a Phillips curve relationship for the Turkish economy employing linear and nonlinear specifications in unemployment rate and unemployment gap, and finds no evidence of a Phillips curve in Turkey. Önder (2004) uses a linear Phillips curve specification with output gap instead of unemployment and finds that it has better forecasting performance than forecasts based on other time series models. Önder (2006) tests the stability of the Phillips curve with output gap and shows that the Phillips curve is non-linear and unstable for Turkey. Domaç (2004) to account for the openness of the Turkish economy adds the nominal exchange rate to the traditional Phillips curve equation with output gap and shows that it outperforms other theoretical models such as mark-up and monetary models. Sarikaya et al. (2005) and Öğünç (2006) instead add real exchange rate to the Phillips curve specification and show that both output gap and real exchange rate depreciation affect inflation positively. The positive affect of output gap on inflation still continues in the case that real exchange rate is excluded from the specification. Öğünç and Ece (2004) also find a positive relationship between output gap and inflation.

two leads of inflation. The other two Phillips curve specifications follow from Taylor (1980) and Fuhrer and Moore (1995) staggered contracts model[35]. However, as argued in Galí and Gertler (1999), Fuhrer and Moore's (1995) and Taylor's (1980) Phillips curve specifications are not derived from an explicit optimizing microeconomic model. Moreover, although Phillips curve equations used in the study do *not* have an open economy context, variables like real exchange rate, relative oil price-nominal wage ratio and imported oil prices measured in domestic-currency terms are included in the specifications to account for openness without any *theoretical* justification. The estimation results are said to support a Taylor (1980) type of a price formation equation for the Turkish economy, although the estimated coefficient of the output gap is found to be negative and insignificant. Furthermore, the variables included to account for openness were either found to be statistically insignificant or of the wrong sign.

Yazgan and Yilmazkuday (2005), although have stressed the importance of imported input costs and the *openness* for the Turkish economy, have employed the *same pure* and *hybrid* NKPC specifications derived in Galí and Gertler (1999) that does *not* take openness into account. The necessity of developing an open economy model for Turkey is discussed in section II.D by giving descriptive analysis. Despite using the closed economy NKPC specification of Galí and Gertler (1999), the consumer price index (CPI) which includes the prices of imported goods is used to calculate the inflation series.

Çatik et al. (2008) have also used Galí and Gertler's (1999) hybrid *closed* economy specification, but they have further developed it into an empirical autoregressive distributed lag (ARDL) model in first differences, augmented by the lagged values of inflation and output gap, with the differenced rate of inflation used as the dependent variable. Thus, the empirical form of the hybrid Phillips curve relationship used in Çatik et al.'s (2008) estimation is very

[35] For details of the analytical specifications of these equations see Agénor and Bayraktar (2010).

different from Galí and Gertler's (1999) original specification. As argued by the authors themselves the ARDL model developed has *no* formal microeconomic foundations. Moreover, although the underlying model used is a *closed* economy model, like Yazgan and Yilmazkuday (2005) the CPI is used to calculate the inflation series.

Celasun (2006) is the *only* study in the Turkish literature that actually derives and estimates a NKPC equation for Turkey from an explicit *open economy intertemporal optimizing* model. Therefore, among the very few NKPC studies applied to Turkey, this is the only study that seems to resemble most the work carried out in this thesis. The NKPC equation of Celasun (2006) is derived and estimated for *nontradables* inflation obtained from the subcategories of the consumer price index (CPI). The specification derived is again equivalent to Galí and Gertler's (1999) hybrid NKPC specification but Galí and Gertler (1999) estimate it for U.S. GDP deflator. The real marginal cost of nontradables is replaced with a combination of the real wage rate and the demand for nontradables. The demand for nontradables is derived as proportional to the real exchange rate and the demand for tradables is proxied by the imports to GDP ratio. The *tradables* in Celasun (2006)'s model are *homogenous* and assumed to be supplied *exogenously* (i.e. there is a given endowment of tradables each period). Moreover the l*aw of one price (LOOP)* is assumed to *hold* for the tradables. On the other hand, for the *nontradables*, endogenous supply is allowed but only with *one factor of production which is labor*.

In the model that we have developed for the Turkish economy, all goods at the beginning are tradable. However, since the size of the small open economy is assumed to be negligible relative to the rest of the world, the output produced in the small open economy is in the limit only purchased by the consumers of the small open economy. Thus, the goods produced in the small open economy become nontradable at the limit. Therefore, by assuming that output in the small open economy is produced not only by domestic labor but also using imported intermediate goods and domestically produced intermediate goods, our production technology is a *generalization* of that used in Celasun (2006). Also, as discussed in section II.D, the production structure of Turkish economy further supports the introduction of imported and domestically produced intermediate inputs into the production technology. Furthermore, in our model, in contrast to Celasun (2006), the imported goods (i.e. tradables) are also assumed to be supplied *endogenously* by the rest of the world. This again offers a more realistic setup than that in Celasun (2006). Moreover, we assume that *LOOP only* holds at the *dock* for imported goods. To ensure deviations from the LOOP in the home economy the imported goods in our model are modeled as *differentiated* goods. This allows the importer firm a degree of *market power* and hence a *choice* over her selling price. The importer firm chooses the domestic currency price of the imported good by solving a dynamic optimization problem, which causes there to be deviations from the LOOP. The *incomplete pass through* assumption allows us to model *import pricing* decisions and thus not only adds richer dynamics to our model when compared to that of Celasun (2006) but also reflects an empirical regularity since, as discussed in section II.D, pass through is indeed found to be incomplete for Turkey.

The NKPC equations that Celasun et al. (2004a, 2004b) employ do have an open economy setting, but rather than deriving the estimated NKPC equation from an explicit micro-founded open economy optimizing model, these studies have also adopted the *same hybrid* equation derived in Galí and Gertler (1999)[36]. The *openness* in both of these studies stems from the different *proxies* used for *marginal cost* that are *not* theoretically justified from a microeconomic optimizing model[37]. Celasun et al. (2004a, 2004b) extend Celasun's (2006)

[36] The hybrid NKPC specifications of Celasun et al. (2004a, 2004b) differ from that of Galí and Gertler (1999) only in the sense that the discount factor parameter is restricted to unity.

[37] In Celasun et al. (2004a), real marginal cost is proxied with a combination of real effective exchange rate and domestic real unit labour costs. On the other hand, Celasun et al. (2004b) proxy real marginal cost with the real wage rate, the real exchange rate, the relative price of tradables with respect to nontradables in the CPI index and the imports to GDP ratio. The first variable is used instead of labor share as a proxy for marginal cost. The second variable is used

NKPC specification for the nontradables component of the CPI to the overall CPI.

The few NKPC studies that are applied to Turkish data provide mixed evidence on the validity of this curve for the Turkish economy. On the one hand, Yazgan and Yılmazkuday (2005) and Celasun et al. (2004a) have found empirical support for Galí and Gertler's (1999) *pure* NPKC equation; on the other hand Celasun (2006) and Celasun et al. (2004b) have showed that the *hybrid* NPKC equation fits Turkish data quite well. Çatik et al. (2008) have showed that a *hybrid* Phillips curve á la Galí and Gertler (1999) exists for Turkey only if the variance and skewness of relative price changes are added to its specification. However, Agénor and Bayraktar (2010) also extending the hybrid closed economy NKPC specification of Galí and Gertler (1999) to include open economy elements (like real exchange rate, relative oil price-nominal wage ratio and imported oil prices) showed that this specification did not perform well for Turkey well when nested and non-nested tests were conducted. While Agénor and Bayraktar (2010) have found that the inflation process in Turkey is highly *backward* looking using a Taylor (1980) type of a price formation equation, Celasun et al. (2004b) have showed that the *forward* looking component of Turkish inflation is statistically more important than the backward looking component. The relative importance of the expected future inflation is further supported by Celasun (2006) using the nontradable component of the CPI index.

II.D SUMMARY

In this chapter, we discussed the historical evolution towards the NKPC and surveyed the vast literature on the NKPC by attempting to give a complete picture of the many disagreements surrounding the NKPC from both a

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as a proxy for the tradable component of the consumer price index (CPI), and the third and fourth variables for the nontradable component of the CPI.

theoretical and an empirical perspective. As the previous discussion shows, the controversies on the closed economy NKPC have focused on three major issues. First of these issues pertain to the choice of variables to be included in the Phillips curve. Should the NKPC include a backward looking component or is the inflation process fully forward-looking? What is the appropriate measure of real marginal cost? Should real economic activity be represented by an output gap or labor share measure? If output gap is chosen, how should it be defined and measured? The second issue has focused on the modeling approach of the NKPC. How should the backward looking component be introduced into the model? How could the NKPC be modeled to introduce some inertia to the inflation process? What are the constraints that firms face in setting their prices and how can they be modeled? The third issue concentrates on the estimation approach to the NKPC. What is the appropriate method to estimate the NKPC model? Should GMM, FIML or other likelihood based methods used to estimate the NKPC? Does the NKPC model explain observed inflation dynamics well using fundamental inflation?

The adaptation of the NKPC to an open economy framework has increased the controversies since now the curve must give a good representation of the price, inflation and exchange rate dynamics. In addition, the relationship between real marginal costs, labour share and output becomes more complicated when producers face a choice between imported and domestic intermediate goods. Modeling price setting also becomes more complex with import pricing and the need to decide on the degree of exchange rate pass through.

The results obtained when NKPC was applied to Turkish data were rather mixed. In contrast to the applications to the U.S. and several Euro area countries, Yazgan and Yılmazkuday (2005) and Celasun et al. (2004a) have found empirical support for the *pure NPKC* specification. However, Celasun (2006) and Celasun et al. (2004b) have shown that the *hybrid* NPKC equation fits Turkish data quite well. While Agénor and Bayraktar (2010) have found that the inflation process in Turkey is highly *backward looking*, Celasun (2006) and Celasun et al. (2004b) have shown that the *forward looking* component of Turkish inflation is statistically more important than the backward looking component.

We have attributed the aforementioned differences to the diverse modeling assumptions used in these studies, especially with regards to the open economy factors introduced. On the one hand, Yazgan and Yılmazkuday (2005) have estimated Galí and Gertler's (1999) closed NKPC specification. On the other hand, Celasun et al. (2004a, 2004b) and Agénor and Bayraktar (2010) have estimated Galí and Gertler's (1999) reduced form hybrid NKPC specification by including variables like the real (effective) exchange rate, the relative oil price-nominal wage ratio, the imported oil prices or the imports to GDP ratio to account for openness without any theoretical justification. Celasun (2006) has derived and estimated a hybrid NKPC equation for Turkey from an explicit open economy intertemporal optimizing model. However, in this model, LOOP is assumed to hold for tradables and nontradables are assumed to be produced with labour only.

Introducing openness to the Turkish model is very important because Turkish economy is an open economy when compared to a number of industrial countries and is even more open than some emerging countries (Ho and McCauley, 2003; Alper, 2003). As apparent in Figure 1, the openness of the Turkish economy when measured as the share of total exports and imports in GDP tends to increase since late 1990's and reaches 54 percent in late 2000's (Figure 1). Another openness criterion, imports ratio to GDP, follows a similar pattern and reaches 31 percent in late 2000's.

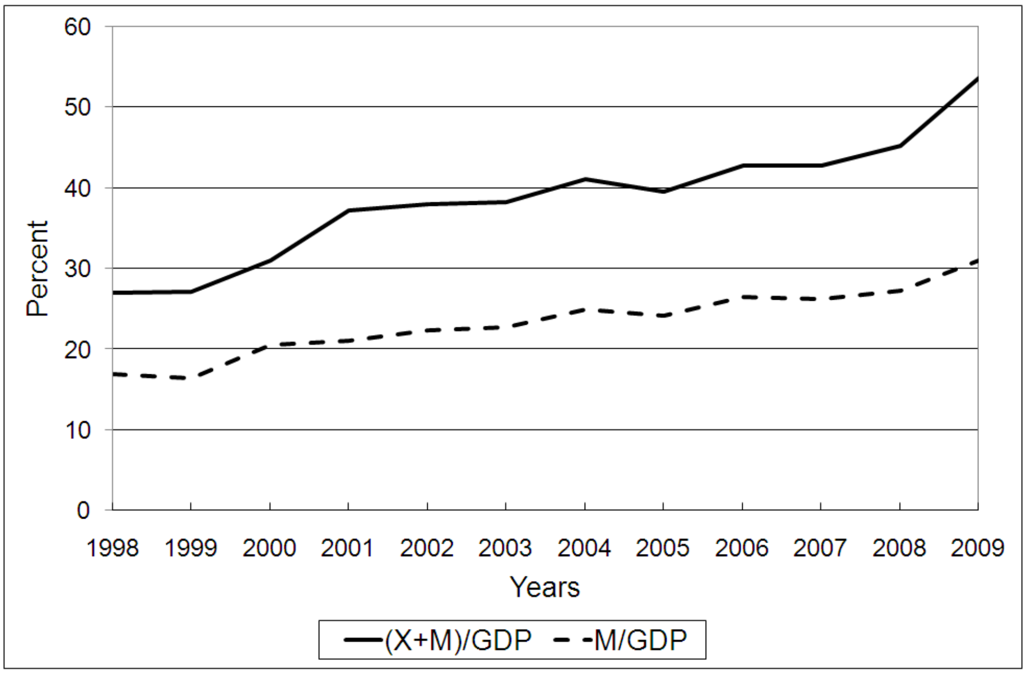

Figure 1 Openness of the Turkish Economy

Source: Author's own calculations based on TurkStat (2009c, 2009d)

In light of Figure 1, in this thesis to explain the inflation dynamics in Turkey we have derived an *open economy* NKPC equation for Turkey from a model that is possibly best suited for the Turkish economy. Among the open economy studies surveyed in subsection II.B.2, two studies have particularly attracted our attention for this purpose. These are the ones by Rumler (2007) and Monacelli (2005). We think that these studies better suit the Turkish economy in their own different respects.

Rumler (2007) has incorporated both *imported and domestically produced intermediate inputs* to the production function of firms. Such an extension is quite important for Turkey because when the 2002 Input-Output Table of Turkish economy is analyzed, it is seen that the total intermediate goods (imported plus domestically produced) constitute 81 percent of the total output of the Turkish economy. Moreover, the inclusion of the *imported intermediate* *goods* in the production function is again especially important for Turkey since relatively small part of the imported goods is final consumer goods with intermediate goods having the largest share (Figure 2). Also the amount spent on imported intermediate goods constitutes a considerable fraction of the costs of firms in the industry. The share of the value of imports in the value of total industry output is equal to 15 percent. Due to this high dependency and the lack of domestically produced substitutes of imported inputs, industrial production and imported intermediate goods follow a very close pattern (Alper, 2003) (Figure 3). This further makes the industry in Turkey very vulnerable to the terms of trade or exchange rate shocks since the prices of the imported intermediate goods are changing more unexpectedly (like the price of oil) and frequently than the prices of domestically produced inputs.

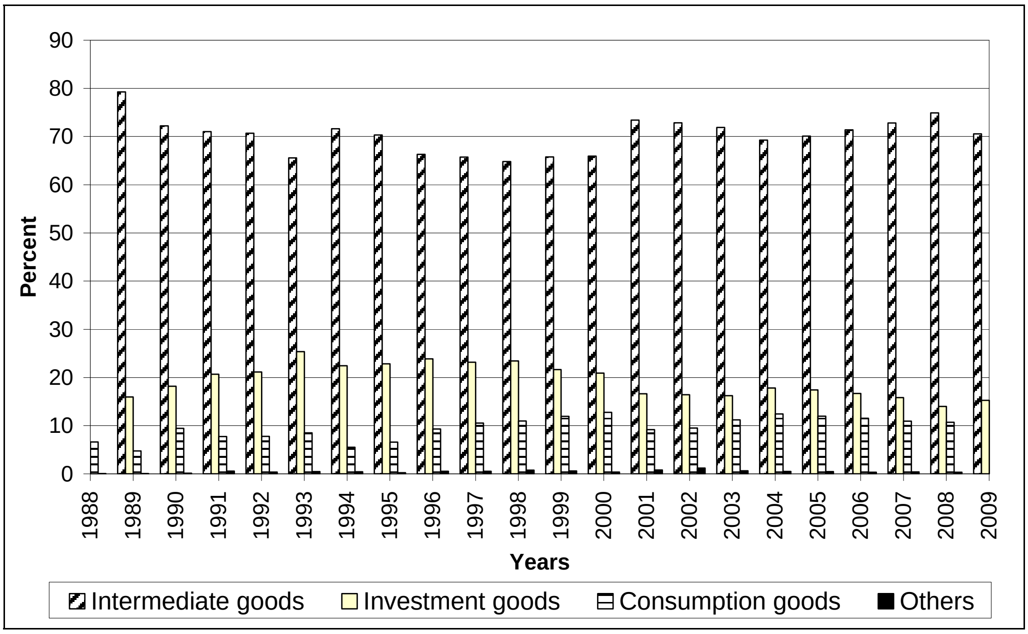

Figure 2 Import Structure of the Turkish Economy

Source: TurkStat (2009d)

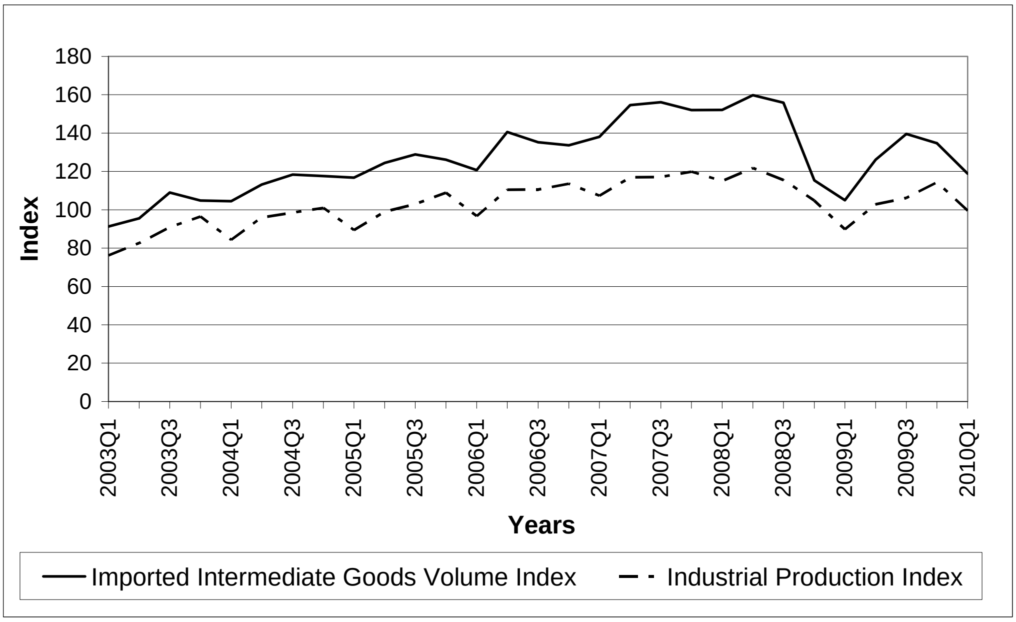

Figure 3 Import Structure of the Turkish Economy

Source: CBRT (2010a)

Monacelli (2005) has developed a model of the world economy in which two asymmetric countries: a small open economy (SOE) and a large approximately closed one coexist. As stated above, it is the first study in the open economy NKPC literature that combines Calvo (1983) type staggered price setting into a model where *incomplete exchange rate pass through* is allowed in the local currency *import* prices.

As discussed in Goldberg and Knetter (1997), most of the theoretical and empirical literature on exchange rate pass through that analyze industrialized countries is concerned with exchange rate pass through to import prices. However, for emerging market economies the literature focuses more on the exchange rate pass through to *domestic prices*, although formally import prices are the first channel of the exchange rate pass-through to domestic inflation. This is motivated by the idea that in small open economies pricing to market behavior is less likely and even if exists it is expected to be small. This causes the studies conducted on small open economies like Turkey to assume complete pass through to import prices a prior and investigate the extent and implications of pass through to domestic prices (Kara and Öğünç, 2008; Kara et al. 2007; Kara and Öğünç, 2005; Leigh and Rossi, 2002). Recently, however, Tekin and Yazgan (2009) using VAR and cointegration analysis have showed that while there is complete pass through in export prices, for import prices the pass through is incomplete even in the long run. Also María-Dolores (2009) using a VAR approach, has showed that in Turkey exchange rate pass through to import prices is high but incomplete both the short and the long run. Furthermore, María-Dolores (2010) using a different methodology has found that short and long run pass through to import price rates are *lowest* in Turkey when compared to the new member states of the European Union.

In light of the discussion made above, the model that we have proposed for Turkey is a combination of the open economy models by Monacelli (2005) and Rumler (2007). By combining a CES-type production function incorporating *imported intermediate goods* with *incomplete exchange rate pass through in import prices*, we have developed a hybrid NKPC formulation that is novel in the literature.

Although our NKPC model draws heavily on the open economy models developed by Rumler (2007) and Monicelli (2005), it departs from these two models in important respects. In Rumler (2007), LOOP is assumed to hold for both imported and exported goods and thereby the NKPC equation is only derived for domestic goods prices. However, in the NKPC model that we have proposed for Turkey, LOOP is assumed to hold only for exported goods and the NKPC equation is derived not only for domestic price inflation but also for imported price inflation and the CPI inflation.

In Monacelli (2005) trade is assumed to take place only at the final goods level and the production technology is specified in the form of a simple Cobb-Douglas function with domestic labour. In addition, only a pure forward looking NKPC specification that implies no intrinsic inflation inertia is derived. However, in our model, trade takes place both at the final and the intermediate goods level and the production technology is generalized by including domestically produced and imported goods to substitute imperfectly with labor. Also, the model that we have developed for Turkey is based on the line of research initiated by Galí and Gertler (1999) and Galí et al. (2001) on the *hybrid* specification of the NKPC. To account for the observed *inertia* in Turkish inflation we have modeled Turkish inflation using a hybrid model rather than a pure forward looking model which is derived and discussed in detail in the next chapter[38].

[38] The strong inertia in Turkish inflation is well documented, among others, in Metin-Özcan, Berument, and Neyaptı (2004), Kibritçioğlu (2002), Erlat (2002), Baum, Barkoulas and Çağlayan (1999) and Alper and Uçer (1998).

CHAPTER III

THE TURKISH NKPC MODEL

In chapter II, two different open economy models were evaluated with respect to their relevance for the Turkish economy. While each model is important and helps us to understand how inflation behaves, albeit in different environments, the two modeling approaches need to pay more attention to one another, and this study represents a start toward that reconciliation.

The model that we propose for Turkey is based on the line of research started by Galí and Gertler (1999) and Galí et al. (2001) on the hybrid specification of the NKPC. It draws heavily on the open economy NKPC models of Rumler (2007) and Monacelli (2005). The model for Turkey is a combination of the open economy models of Monacelli (2005) and Rumler (2007).

By combining a CES-type production function incorporating *imported* and *domestically* produced intermediate goods with *incomplete exchange rate pass through* in import prices, we have proposed a NKPC formulation that is novel in the literature. Thereby, in our model, not only imported and domestically produced intermediate inputs are used in the production process substituting labor imperfectly, but also incomplete *exchange rate pass through* is integrated into the imported goods prices and thereby the domestic goods prices. In this model, trade takes place both at the intermediate and final goods production levels and deviations from the *law of one price (LOOP)* are allowed for the imported goods whether they are used as intermediate goods in production or final goods in consumption.

Following Monacelli (2005) we have developed a model of the world economy in which *two asymmetric countries*, *a small open economy and a large approximately closed one*, coexist. In the economy there are basically *three* agents: a representative household consuming domestically produced and imported goods, a domestic firm operating in a monopolistically competitive market and producing a differentiated product using domestically and imported intermediate inputs as well as labor, and a local retailer that imports a differentiated good and operates as a price setter in the domestic market.

The *representative household* chooses processes N_t (hours of labor) and C_t [total consumption that is defined as a composite consumption index, comprised of the index of domestically produced goods ($C_{H,t}$) and index of foreign produced goods ($C_{F,t}$)] for all dates $t \geq 0$ that maximize

$$E_0 \sum_{t=0}^{\infty} f\left(C_t, N_t\right)$$

subject to

$$\int_{z=0}^{1} \left[P_{H,t}(z)C_{H,t}(z) + P_{F,t}(z)C_{F,t}(z)\right] dz + E_t\left\{Q_{t,t+1}D_{t+1}\right\} \leq D_t + W_t N_t$$

given the wage rate (W_t), domestic price of good *z* ($P_{H,t}(z)$), domestic currency import price of good *z* ($P_{F,t}(z)$) and asset prices (indicated by the stochastic discount factors $Q_{t,t+1}$) where $f(.)$ is the utility function, D_t denotes the nominal payoff in period *t* of the portfolio held at the end of period *t-1* and $Q_{t,t+1}$ denotes the stochastic discount factor for discounting nominal payoffs in period *t+1* back to an earlier period *t*.

The *representative domestic firm* chooses $P^{f}_{H,t}(z)$ (the optimal forward looking reset price of the z^{th} good domestically produced) at each point in time to maximize the expected discounted real profits over the course of the contract[39]:

$$E_t \sum_{s=0}^{\infty} \beta^s \theta^s \left[\frac{P^{f}_{H,t}(z) Y_{t+s}(z)}{P_{t+s}} - TC_t(z) \right]$$

subject to

$$Y_t(z) = \left(\frac{P^{f}_{H,t}(z)}{P_{H,t}} \right)^{-\kappa} \left(C_{H,t} + M_{H,t} \right)$$

and

$$TC_t(z) = Y_t(z)^{\phi} \widetilde{MC_t}$$

given the prices ($P_{H,t}(z)$ and P_t) where β is a discount factor, θ^s is the probability that the forward looking price $P^{f}_{H,t}(z)$ set for the domestic good *z* at time *t* still holds *s* periods ahead, *$TC_t(z)$* denotes the real total variable cost function, $Y_t(z)$ denotes the differentiated good produced by firm *z*, $M_{H,t}$ denotes the domestically produced intermediate input, $\widetilde{MC_t}$ denotes the *non-firm specific* real marginal cost and P_t is the consumer price index (CPI).

The *representative importing firm* chooses $P^{f}_{F,t}(z)$ (the optimal forward looking domestic price set for the imported good *z*) at each point in time to maximize

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[39] In our model there are two types of firms: a backward looking firm and a forward looking firm. The details are discussed in subsection III.B.3.

$$E_t \sum_{s=0}^{\infty} \beta^s \theta^s \left(P^f_{F,t}(z) - \left(P^*_{F,t+s}(z) / E_{t+s} \right) \right) \left(C_{F,t+s}(z) + M_{F,t+s}(z) \right)$$

subject to

$$C_{F,t+s}(z) = \left(\frac{P^f_{F,t}(z)}{P_{F,t+s}} \right)^{-k} C_{F,t+s}$$

and

$$M_{F,t+s}(z) = \left(\frac{P^f_{F,t}(z)}{P_{F,t+s}} \right)^{-k} M_{F,t+s}$$

given the prices of imported goods ($P_{F,t}(z)$) where $P^*_{F,t+s}(z)$ is the foreign currency price of the imported good *z* in period *t+s*, E_{t+s} is the level of the nominal exchange rate in period *t+s* defined as the foreign currency price of a domestic currency, $C_{F,t+s}(z)$ denotes the imported good *z* consumed as final good in period *t+s* and $M_{F,t+s}(z)$ denotes the imported intermediate good *z* used in period *t+s* for domestic production.

The *goods market equilibrium condition* holds for the *z*-th domestic product and can be expressed in the following form:

$$Y_t(z) = C_{H,t}(z) + M_{H,t}(z) + C^*_{H,t}(z) + M^*_{H,t}(z)$$

where the domestic output of firm *z* ($Y_t(z)$) amounts to the demand for its consumption good at home and abroad, $C_{H,t}(z)$ and $C^*_{H,t}(z)$, as well as for its output employed as intermediate input by domestic and foreign firms, $M_{H,t}(z)$ and $M^*_{H,t}(z)$.

We describe the environment and derive the optimizing behaviors of the representative household, domestic firm and importing firm in detail in subsections III.A, III.B and III.C. Finally by aggregating their behavior we derive the basic CPI based NKPC equation and explain its determinants in section III.D.

III.A HOUSEHOLDS

In this part, we introduce basic principles related to the behavior of a representative household and its connection to the foreign economy. Optimization problems of the representative household are solved in subsection III.A.1. The basic relationships among inflation, the real exchange rate and terms of trade are presented with special emphasis on exchange rate *pass through* in subsection III.A.2.

III.A.1 Optimization

The representative household in this economy seeks to maximize the *discounted value of expected utility* expressed as a utility from consumption reduced by a disutility from amount of hours of labor

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[U(C_t) - V(N_t) \right] \tag{3.1}$$

where $0<\beta<1$ is a discount factor, N_t denotes hours of labor and C_t represents a composite consumption index that is comprised of the index of domestically produced goods (denoted by $C_{H,t}$) and the index of foreign produced (imported) goods (denoted by $C_{F,t}$) given by:

$$C_t = \left[(1-\gamma)^{1/\eta} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{1/\eta} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3.2}$$

where $\eta > 0$ denotes the elasticity of substitution between home and foreign consumption bundles, and γ ($0 \leq \gamma \leq 1$) denotes the share of imported (final) goods in the domestic consumption basket and thus serves as an index of openness[40].

By assuming a CES type of aggregate consumption bundle, we are implicitly assuming that the goods produced at home and abroad are imperfect substitutes and therefore are to be treated differently by the representative household in solving its optimization problem.

The home and imported consumption good indices are given by CES aggregators of the quantities consumed of each type of good $z \in (0,1)$ [41]:

$$C_{H,t} = \left[\int_0^1 C_{H,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \qquad (3.3)$$

and

$$C_{F,t} = \left[\int_0^1 C_{F,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \qquad (3.4)$$

where $\kappa > 1$ denotes the elasticity of substitution between goods produced within one country[42]. The elasticity of substitution between countries (η) is assumed to be different than the elasticity of substitution within countries (κ).

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[40] The degree of openness is inversely related to the home bias in consumption. When the share of domestic consumption allocated to imported goods increases (γ), the home bias in preferences decreases.

[41] We suppose a continuum of goods indexed by *z*, which is normalized to be between 0 and 1. In the discrete commodity formulation with *N* goods, the home index can be written as $C_H = \left[\sum_{z=1}^{N} C_{H,z}{}^{(\kappa-1)/\kappa} \Delta z \right]^{\kappa/(\kappa-1)}$, where $\Delta z = 1$. The representation under a continuum of goods takes the limit of the sums given by the integral formulation in (3.3). The same holds for the foreign index C_F.

The period utility function is assumed to be given by the *constant relative risk aversion* (CRRA) utility function (or *constant intertemporal elasticity of substitution* (CIES) utility function):

$$U(C_t) = \frac{C_t^{1-\sigma}}{1-\sigma} \tag{3.5}$$

where $\sigma > 0$ denotes the inverse of the intertemporal elasticity of consumption[43].

The period disutility of work function is given by:

$$V(N_t) = \frac{N_t^{1+\varphi}}{1+\varphi} \tag{3.6}$$

where φ gives the inverse of the intertemporal elasticity of substitution in labor[44].

Households are assumed to have access to a complete set of state contingent claims traded internationally[45]. Maximization of equation (3.1) is subject to the

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[42] Following Monacelli (2005), without loss of generality, we can assume the same value of κ for both domestic and imported goods.

[43] For this utility function, the intertemporal substitution elasticity between consumption in any two periods that measures the willingness to substitute consumption between different periods is the constant *1/σ*. The higher is *σ*, the more rapid is the proportionate decline in marginal utility of consumption in response to increases in consumption and, hence, the less willing households are to accept deviations from a uniform pattern of consumption over time. Also note that *σ* is the coefficient of relative risk aversion. Since the coefficient of relative risk aversion is indepent of consumption, this utility function is also known as the constant relative risk aversion (CRRA) utility function.

[44] For this disutility of work function, the intertemporal elasticity of substitution in labor equals *1/φ*. It measures the willingness to substitute hours of labor between different periods. The higher is *φ* , the more rapid is the proportionate decline in marginal disutility of labor supply in response to increases in labor supply and, hence, the less willing households are to accept substitute labor over time This elasticity is also known as the “Frisch elasticities of labor supply”.

following sequence of flow intertemporal budget constraints, where an income from nominal wages and payoff from a portfolio are used for paying for consumption and a new portfolio:

$$\int_{z=0}^{1} \left[P_{H,t}(z)C_{H,t}(z) + P_{F,t}(z)C_{F,t}(z) \right] dz + E_t \left\{ Q_{t,t+1} D_{t+1} \right\} \leq D_t + W_t N_t \tag{3.7}$$

In the above equation, $P_{H,t}(z)$ and $P_{F,t}(z)$ denote the price of the *z-th* domestic produced and imported good, D_t is the nominal payoff in period t of the portfolio held at the end of period $t-1$ (and which includes shares in firms) and W_t is the nominal wage rate[46]. All the variables aforementioned are expressed in domestic currency. $Q_{t,t+1}$ denotes the stochastic discount factor for discounting nominal payoffs in period $t+1$ back to an earlier period t. Expectations are conditional upon all the information available at t, which we denote by Ω_t.

Given equations (3.1) – (3.7), *three* sets of optimality conditions can be derived for the representative household's problem in the home country. First two of these are static, but the last one follows from an intertemporal optimization problem.

First, the household's total consumption spending must be allocated optimally between home and foreign goods at each point in time, taking as given the overall level of expenditure on the composite consumption good, C_t. Thus, the relative expenditures on home and foreign goods must be so as to maximize the composite consumption index C_t in equation (3.2), given the level of total

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[45] As discussed in Woodford (2003, p. 64), this ensures that available financial assets completely span the relevant uncertainty faced by households about future income, prices, and so on, so that each household faces a single intertemporal budget constaint.

[46] Following Galí and Monacelli (2005) we assume that money does not appear in either the budget constraint or the utility function. For a more detailed discussion refer to Galí and Monacelli (2005).

expenditure on home and foreign goods. In the static problem facing a domestic consumer who wants to maximize

$$C_t = \left[(1-\gamma)^{1/\eta} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{1/\eta} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3.8}$$

subject to

$$I_{HF} = P_{H,t} C_{H,t} + P_{F,t} C_{F,t} \tag{3.9}$$

where I_{HF} is a given level of total expenditure on home and foreign goods; the *indirect consumption function* (i.e. indirect objective function) is solved as $\upsilon(P_{H,t}, P_{F,t}; I) = I \Big/ \left[(1-\gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{1/(1-\eta)}$, the appropriate price index is:

$$P_t = \left[(1-\gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{3.10}$$

the optimal domestic *demand* for the domestically produced consumption (home) goods is:

$$C_{H,t} = (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t \tag{3.11}$$

and the optimal domestic demand for imported goods is:

$$C_{F,t} = \gamma \left(\frac{P_{F,t}}{P_t} \right)^{-\eta} C_t \tag{3.12}$$

P_t in equation (3.10) is the consumer price index (CPI) that minimizes the cost of purchasing one unit of the composite consumption good, C_t[47].

Note that in equations (3.11) and (3.12), the household's decision of dividing the expenditure between domestic and imported consumption is influenced by an extent of the total consumption C_t, a possibility to consume imported goods (expressed by the degree of openness of the economy γ) and relative price of domestically produced goods ($P_{H,t}/P_t$) and imported goods ($P_{F,t}/P_t$) with the influence of a possibility to substitute (parameter η) between these two groups of goods.

Second, the household's home and foreign consumption spending must be optimally allocated across differentiated goods within each category at each point in time, taking as given the overall level of expenditure on each category (i.e. expenditure on the home consumption index $C_{H,t}$ and the foreign consumption index $C_{F,t}$)[48]. Thus, the relative expenditures on the different varieties of the *home good* must be so as to maximize the home consumption index (3), given the level of total expenditure on the varieties of the home good. In this case the problem that the representative household faces is to maximize:

$$C_{H,t} = \left[\int_0^1 C_{H,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.13}$$

[47] This price index can also be obtained by solving the expenditure minimization problem that is the dual problem of (3.8) – (3.9) and by deriving the expenditure function. The expenditure function gives the minimum cost of purchasing the composite consumption bundle (C_t) for any level of home and foreign prices and the unit of the composite consumption good. Then the price index that minimizes the cost of purchasing a single unit of the composite consumption bundle is found simply by putting 1 in place of C_t. Since the two problems are dual problems, without solving the expenditure minimization problem, the appropriate price index can be obtained directly by solving the indirect consumption function.

[48] Implicitly consumers pursue a 2-step optimization problem by first allocating their demand across countries and then across goods within a country.

subject to

$$\int_0^1 C_{H,t}(z)P_{H,t}(z)dz = I_H \tag{3.14}$$

where I_H is a given level of total expenditure on domestic goods. The solution to this problem requires the demand for a specific domestic firm's consumption good z to satisfy[49]:

$$C_{H,t}(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\kappa} C_{H,t} \tag{3.15}$$

for all $z \in (0,1)$ where

$$P_{H,t} = \left(\int_{z=0}^{1} P_{H,t}(z)^{1-\kappa} dz\right)^{\frac{1}{1-\kappa}} \tag{3.16}$$

is the appropriate price index for the domestic goods.

Likewise, the relative expenditures on the different varieties of the imported *foreign good* must be such as to maximize the foreign consumption index (3.4) given the level of total expenditure on the varieties of the imported foreign

[49] In the discrete commodity static problem facing a consumer who wants to maximize

$$C_H = \left[C_1^{(\kappa-1)/\kappa} + C_2^{(\kappa-1)/\kappa}\right]^{\kappa/(\kappa-1)} \text{ subject to } I = P_1C_1 + P_2C_2$$

where I is a given level of total expenditure (or income), the indirect consumption function is solved as

$$\upsilon(P_1, P_2; I) = \frac{I}{\left[P_1^{1-\kappa} + P_2^{1-\kappa}\right]^{1/1-\kappa}},$$

the appropriate price index is $P_H = \left[P_1^{1-\kappa} + P_2^{1-\kappa}\right]^{1/(1-\kappa)}$, and the individual's demand for good j=1,2 is $C_j = \left[P_j/P_H\right]^{-\kappa}\left(I/P_H\right)$, where ($I/P_H$) is real expenditure (or real income) and equals C_H from duality.

good. Thus, the problem that the representative household faces is to maximize:

$$C_{F,t} = \left[\int_0^1 C_{F,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.17}$$

subject to

$$\int_0^1 C_{F,t}(z) P_{F,t}(z) dz = I_F \tag{3.18}$$

where I_F is a given level of total expenditure on imported goods. Analogous to the solution of the problem given in (3.13) and (3.14), this requires the demand for a specific imported foreign consumption good *z* to satisfy:

$$C_{F,t}(z) = \left(\frac{P_{F,t}(z)}{P_{F,t}} \right)^{-\kappa} C_{F,t} \tag{3.19}$$

for all $z \in (0,1)$ where

$$P_{F,t} = \left(\int_{z=0}^{1} P_{F,t}(z)^{1-\kappa} dz \right)^{\frac{1}{1-\kappa}} \tag{3.20}$$

is the appropriate price index for the imported goods (expressed in units of domestic currency).

Third, taking as given the optimal allocations of consumption spendings across and within countries at each point in time – equations (3.11), (3.12), (3.15) and (3.19) - the household must maximize the utility function (3.1) with respect to N_t, C_t, and D_{t+1} subject to equation (3.7), given the specific forms for the utility and disutility functions in equations (3.5) and (3.6). With the *optimality* *conditions* given in equations (3.11), (3.12), (3.15) and (3.19), the first term on the left hand side of equation (3.7) becomes $\int_{z=0}^{1} \left[P_{H,t}(z) C_{H,t}(z) + P_{F,t}(z) C_{F,t}(z) \right] dz = P_{H,t} C_{H,t} + P_{F,t} C_{F,t} = P_t C_t$. Utilizing this fact causes equation (3.7) to reduce to:

$$P_t C_t + E_t \left\{ Q_{t,t+1} D_{t+1} \right\} \leq D_t + W_t N_t \tag{3.21}$$

The solution to the maximization of discounted sum of utilities given in equation (3.1) now subject to equation (3.21), gives the remaining optimality conditions of the household problem as[50]:

$$C_t^{\sigma} N_t^{\varphi} = \frac{W_t}{P_t} \tag{3.22}$$

and

$$\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) = Q_{t,t+1} \tag{3.23}$$

Taking conditional expectations on both sides of (3.23) and noting that $R_t = 1 \big/ E_t \left\{ Q_{t,t+1} \right\}$ where R_t is the gross return on a riskless one-period discount bond paying off one unit of domestic currency in *t+1*, equation (3.23) can be rewritten as:[51]

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[50] Although here we have written the complete set of optimality conditions for the representative household including the ones arising from intertemporal utility maximization, to study firms' pricing decisions and derive the NKPC, we only require the conditions that show how consumer's allocate their consumption spending across domestic and foreign goods.

[51] The gross return, R_t, is in fact equal to (1+ i_t) where i_t is the riskless short term (one-period) nominal interest rate.

$$\beta R_t E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right\} = 1 \tag{3.24}$$

Equation (3.22) gives the intratemporal consumption which balances marginal utility of consumption to marginal value of labor and equation (3.24) expresses the intertemporal Euler equation.

In the rest of the world (ROW), a *representative foreign household* faces the same optimization problems as the representative household in the home country. Hence, a similar set of optimality conditions can be obtained for the solution to the consumer's problem in the world economy.

Let $C_t^*, C_{H,t}^*, C_{F,t}^*, C_{H,t}^*(z)$ and $C_{F,t}^*(z)$ denote the composite consumption index of the ROW, the index of home goods consumed by the ROW, the index of foreign produced goods consumed by the ROW, the home good *z* consumed in the ROW and the foreign produced good *z* consumed in the ROW, respectively. In addition, $P_t^*, P_{H,t}^*, P_{F,t}^*, P_{H,t}^*(z)$ and $P_{F,t}^*(z)$ denote the CPI of the ROW denominated in foreign currency, the price index of domestically produced goods denominated in foreign currency, the price index of foreign produced goods denominated in foreign currency, the foreign currency price of a home good z and the foreign currency price a foreign good *z*, respectively.

The representative foreign consumer in the ROW then solves problems analogous to (3.8) - (3.9), (3.13) - (3.14) and (3.17) - (3.18), to optimally allocate her expenditure first between and then within home and foreign goods. Solutions to these problems result the foreign demand for domestically produced consumption goods to satisfy (where a star denotes foreign variables henceforth):

$$C_{H,t}^{*} = \gamma^{*}\left(\frac{P_{H,t}^{*}}{P_{t}^{*}}\right)^{-\eta} C_{t}^{*} = \gamma^{*}\left(\frac{E_{t}P_{H,t}}{P_{t}^{*}}\right)^{-\eta} C_{t}^{*} \qquad (3.25)$$[52, 53]

the foreign demand for consumption goods produced in the ROW to satisfy

$$C_{F,t}^{*} = (1-\gamma^{*})\left(\frac{P_{F,t}^{*}}{P_{t}^{*}}\right)^{-\eta} C_{t}^{*} \qquad (3.26)$$[54, 55]

the foreign demand for domestically produced good z to satisfy

$$C_{H,t}^{*}(z) = \left(\frac{P_{H,t}^{*}(z)}{P_{H,t}^{*}}\right)^{-\kappa} C_{H,t}^{*} = \left(\frac{E_{t}P_{H,t}(z)}{E_{t}P_{H,t}}\right)^{-\kappa} C_{H,t}^{*} = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\kappa} C_{H,t}^{*} \qquad (3.27)$$[56, 57]

and the foreign demand for consumption good z produced in the ROW to satisfy

$$C_{F,t}^{*}(z) = \left(\frac{P_{F,t}^{*}(z)}{P_{F,t}^{*}}\right)^{-\kappa} C_{F,t}^{*} \qquad (3.28)$$[58, 59]

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[52] The second equality follows from the assumption that the pass through of exchange rate changes to export prices is complete. This assumption will be discussed in detail in the next section.

[53] This equation is similar to equation (3.12) which appears in the domestic country counterpart of the consumer problem.

[54] Compared to equation (3.25) here no further simplifications could be made because we assume that the pass through of exchange rate changes to import prices is incomplete. This assumption will be discussed in detail in the next section.

[55] This equation is similar to equation (3.11) which appears in the domestic country counterpart of the consumer problem.

[56] See footnote 15.

[57] This equation is similar to equation (3.15) which appears in the domestic country counterpart of the consumer problem.

[58] See footnote 16.

for all $z \in (0,1)$ where E_t is the nominal exchange rate at t defined as the price of domestic currency in terms of foreign currency (i.e. an increase in E_t represents an *appreciation* of the home currency).

The foreign indices, which are similar to their domestic counterparts, are given by

$$C_t^* = \left[(1-\gamma^*)^{1/\eta} C_{F,t}^{*\,\frac{\eta-1}{\eta}} + (\gamma^*)^{1/\eta} C_{H,t}^{*\,\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3.29}$$

$$C_{H,t}^* = \left[\int_0^1 C_{H,t}^*(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.30}$$

$$C_{F,t}^* = \left[\int_0^1 C_{F,t}^*(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.31}$$

$$P_t^* = \left[(1-\gamma^*)^{1/\eta} P_{F,t}^{*\,\frac{\eta-1}{\eta}} + (\gamma^*)^{1/\eta} P_{H,t}^{*\,\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3.32}$$

$$P_{H,t}^* = \left[\int_0^1 P_{H,t}^*(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.33}$$

and

$$P_{F,t}^* = \left[\int_0^1 P_{F,t}^*(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.34}$$

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[59] This equation is similar to equation (3.19) which appears in the domestic country counterpart of the consumer problem.

Following Monacelli (2005), we assume the size of the small open economy to be negligible relative to the foreign economy - rest of the world, which allows the treatment of the rest of the world as if it was a closed economy[60]. The foreign sector is exogenous but it influences the behavior of the domestic agents. On the other hand, the foreign economy is not influenced by the home economy and therefore the imports of home goods have a negligible influence on the foreign economy. Formally, this can be done by deriving the optimality conditions (3.25) – (3.28) for the world consumer and then focusing on the limiting case where the weight on goods produced in the small economy approaches zero (i.e. $\gamma^* \to 0$). This causes $C^*_{H,t} \to 0$, $C^*_{F,t} \to C^*_t$ and $P^*_t \to P^*_{F,t}$.

III.A.2 Pass Through, Real Exchange Rate, Terms of Trade, Inflation: Important Definitions

Log-linearizing the CPI expression (3.10) around a steady state with $P_{H,t} = P_{F,t}$ yields

$$p_t = (1-\gamma)p_{H,t} + \gamma p_{F,t} \tag{3.35}$$

where the lower case letters denote the logarithmic deviations of the variables from their respective steady state values (i.e. for any variable X_t, the log deviation of X_t is given by $x_t = \ln\left(\frac{X_t}{\bar{X}}\right)$ where $\bar{X}$ denotes the steady state value of the variable X_t). First difference equation (3.35) to obtain:

$$\pi_t = (1-\gamma)\pi_{H,t} + \gamma\pi_{F,t} \tag{3.36}$$

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[60] As argued in Monacelli (2005), this kind of setup allows the explicit modeling of the role of financial markets and risk sharing and to overcome a typical problem of unit-root in consumption that characterizes traditional small open economy models with incomplete markets.

In this equation π_t represents the *CPI inflation* (i.e. $\pi_t = p_t - p_{t-1}$), $\pi_{H,t}$ represents the *domestic goods inflati*on (i.e. $\pi_{H,t} = p_{H,t} - p_{H,t-1}$), and $\pi_{F,t}$ represents the *imported goods inflation* (i.e. $\pi_{F,t} = p_{F,t} - p_{F,t-1}$).

Terms of trade in this economy can be defined as the price of imported goods per unit price of domestic goods, $S_t = P_{F,t} / P_{H,t}$ or in log deviations as,

$$s_t = p_{F,t} - p_{H,t} \tag{3.37}$$

Substituting equation (3.37) into equation (3.35), one can obtain:

$$p_t = p_{H,t} + \gamma s_t \tag{3.38}$$

The first difference of equation (3.38) yields a connection between the overall CPI inflation, the domestic inflation and the terms of trade:

$$\pi_t = \pi_{H,t} + \gamma \Delta s_t \tag{3.39}$$

According to equation (3.39), the difference between overall and domestic inflation is proportional to the change in the terms of trade – the higher the degree of openness (γ), the smaller the required change in the terms of trade.

As discussed in subsection III.A.1, since the world economy is treated as an approximately closed one, for the world economy there is an equality between domestic and CPI inflation. Thus,

$$p_t^* = p_{F,t}^* \tag{3.40}$$

and

$$\pi_t^* = \pi_{F,t}^* \quad \text{for all } t \tag{3.41}$$

Assuming that the law of one price (LOOP) holds for every good *z* would mean that,

$$P_{F,t}(z)E_t = P_{F,t}^*(z) \tag{3.42}$$

and

$$P_{H,t}(z)E_t = P_{H,t}^*(z) \tag{3.43}$$

for all $z \in (0,1)$, where E_t is the nominal exchange rate defined before as the price of domestic currency in terms of foreign currency. Integrating over all goods and after log-linearization, equations (3.42) and (3.43) can be rewritten as

$$p_{F,t} + e_t = p_{F,t}^* \tag{3.44}$$

$$p_{F,t} + e_t = p_t^* \tag{3.45}$$

and

$$p_{H,t} + e_t = p_{H,t}^* \tag{3.46}$$

In writing equation (3.45) from (3.44) we utilized equation (3.40).

However, as in Monacelli (2005), we assume that the pass through of exchange rate changes to *import prices* is *incomplete*, but LOOP continues to hold for the export prices. Thus, we say that, there is producer currency pricing (PCP) in the exported goods market and complete pass through in export prices.

Therefore, while equations (3.42) and (3.45) are no longer valid, the export price of the home good *z*, $P_{H,t}^{*}(z)$, and the export price index (in log-deviations), $p_{H,t}^{*}$, are still determined by equations (3.43) and (3.46).

Before continuing any further, let us try to explain this terminology. In case of *producer currency pricing* (PCP), as the name suggests, the price of the exported goods are set in units of the producer currency and the price that it sells in the importing country is determined by the exchange rate. Therefore, when there is PCP, it is said that there is complete exchange rate pass through (or in other words the pass through of exchange rate changes to import prices is complete): Domestic currency price of imports are totally responsive to exchange rate movements in the short run. At the other extreme case, there is *local currency pricing* (LCP), where the price of the exported good is denominated in terms of the importing country currency. Since in this case the domestic currency price of imported goods are totally unresponsive to exchange rate movements in the short run, the exchange rate pass through is said to be zero. In between these extreme cases, there is incomplete exchange rate pass through.

Since equation (3.45) no longer holds, we can express the deviation of the world price (in domestic currency) from the domestic price of imports (price of imports expressed in domestic currency) in the following form:

$$\Psi_{F,t} = \frac{P_t^{*}(1/E_t)}{P_{F,t}} \tag{3.47}$$

or in log deviations as

$$\psi_{F,t} = (p_t^{*} - e_t) - p_{F,t} \tag{3.48}$$

It is clear from equation (3.45) that, if LOOP holds exactly so that $\Psi_{F,t} = 1$ or $\psi_{F,t} = 0$, there is an equality between the foreign price index and the import price index expressed in domestic currency. Thus, $\psi_{F,t}$, which is a measure of the deviations from the LOOP, will be defined as the LOOP gap.

The real exchange rate can be defined in log-deviations as follows:

$$q_t = p_t - p_t^* + e_t \tag{3.49}$$

where q_t denotes the real exchange rate. Equation (3.49) can be reformulated into the following form using equations (3.37) and (3.38):

$$q_t = e_t + p_t - p_t^*$$

$$q_t = e_t + (p_{H,t} + \gamma s_t) - p_t^*$$

$$q_t = e_t + (p_{H,t} + \gamma s_t) - p_t^* + p_{F,t} - p_{F,t}$$

$$q_t = (e_t + p_{F,t} - p_t^*) - (1-\gamma)s_t$$

$$q_t = -\psi_{F,t} - (1-\gamma)s_t \tag{3.50}$$

or

$$\psi_{F,t} = -q_t - (1-\gamma)s_t \tag{3.51}$$

Moreover, when the LOOP holds for every good *z* including the imported goods, the only source of fluctuation in the real exchange rate (i.e. deviations from aggregate PPP) comes from the variations in the terms of trade. However, once the LOOP is relaxed for the imported goods, the LOOP gap itself acts as a source of deviation from the aggregate PPP.

III.B DOMESTIC FIRMS

We introduce basic characteristics connected with the behavior of a representative domestic firm. The first subsection describes the production possibilities of the home economy. Then, subsection III.B.2 presents the goods market equilibrium condition for the domestic economy. Finally, the last subsection derives the hybrid Phillips curve specification in connection with the price setting behavior of a representative firm.

III.B.1 Production

The aggregate output of the home economy is described by the constant elasticity of substitution (CES) function:

$$Y_t = \left[\int_0^1 Y_t(z)^{\frac{(\kappa-1)}{\kappa}} dz \right]^{\frac{\kappa}{(\kappa-1)}} \tag{3.52}$$

where κ is the elasticity between different types of goods $Y_t(z)$.

The economy is populated by a continuum of monopolistically competitive firms producing differentiated good $Y_t(z)$. Every domestic firm, to produce a differentiated good indexed by $z \in (0,1)$ that is sold in a monopolistically competitive market, uses not only labor supplied by the domestic household, but also fixed capital, imported intermediate goods, and domestically produced intermediate goods. Monopolistically competitive firms sell their products to domestic and foreign consumers as final good and to domestic and foreign firms as intermediate good. The production function used by each monopolistically competitive firm $z \in (0,1)$ is a CES type of production function given by:

$$Y_t(z) = \left(\alpha_N N_t(z)^{\frac{(\rho-1)}{\rho}} + \alpha_H M_{H,t}(z)^{\frac{(\rho-1)}{\rho}} + \alpha_F M_{F,t}(z)^{\frac{(\rho-1)}{\rho}} \right)^{\frac{\rho}{(\rho-1)}\frac{1}{\phi}} \overline{K}^{1-\frac{1}{\phi}} \quad (3.53)$$

where $N_t(z)$, $M_{H,t}(z)$, $M_{F,t}(z)$, $\overline{K}$ denote domestic labor, domestically produced intermediate input, imported intermediate input, fixed capital input used in the production of differentiated good *z*, respectively. The first three factors of production enter as imperfect substitutes in a constant elasticity of substitution (CES) type of production function. The parameter ρ denotes the constant elasticity of substitution between these inputs that are imperfect substitutes. Fixed capital is included to have increasing marginal cost, so that, when a fixed production factor is combined with variable factors of production there are diminishing marginal productivity and increasing marginal cost. If no such fixed input was used in the production process, marginal cost would be constant. The parameter $1-(1/\phi)$ gives the weight of fixed capital in production with $\phi > 1$.

The *real* marginal cost function of any firm *z*, which will be used in subsection III.B.3.2 to derive the empirical counterpart of the hybrid NKPC for domestic inflation, can be derived in three steps. First, the firm's cost minimization problem is solved and the conditional factor demands are obtained. Thus, each firm minimizes the total variable cost of production[61]

$$W_t N_t(z) + P_{H,t} M_{H,t}(z) + P_{F,t} M_{F,t}(z) \quad (3.54)$$ [62]

[61] We ignore the fixed costs of utilizing capital in the firm's problem because we want to obtain the marginal cost function which is obtained by taking the derivative of the total variable cost function with respect to output.

[62] There is perfect competition in the factor markets and every firm *z* takes input prices as given, so that all firms face a common *W*, $P_{H,t}$ and $P_{F,t}$.

subject to the production constraint

$$Y_t(z) = \left(\alpha_N N_t(z)^{\frac{(\rho-1)}{\rho}} + \alpha_H M_{H,t}(z)^{\frac{(\rho-1)}{\rho}} + \alpha_F M_{F,t}(z)^{\frac{(\rho-1)}{\rho}} \right)^{\frac{\rho}{(\rho-1)}\frac{1}{\phi}} \bar{K}^{1-\frac{1}{\phi}} \tag{3.55}$$

to obtain the following conditional factor demands

$$N_t(z) = Y_t(z)^{\phi} \bar{K}^{1-\phi} \left(\alpha_N + \alpha_H \left(\frac{\alpha_N P_{H,t}}{\alpha_H W_t} \right)^{1-\rho} + \alpha_F \left(\frac{\alpha_N P_{F,t}}{\alpha_F W_t} \right)^{1-\rho} \right)^{\frac{\rho}{1-\rho}} \tag{3.56}$$

$$M_{H,t}(z) = Y_t(z)^{\phi} \bar{K}^{1-\phi} \left(\alpha_H + \alpha_N \left(\frac{\alpha_H W_t}{\alpha_N P_{H,t}} \right)^{1-\rho} + \alpha_F \left(\frac{\alpha_H P_{F,t}}{\alpha_F P_{H,t}} \right)^{1-\rho} \right)^{\frac{\rho}{1-\rho}} \tag{3.57}$$

and

$$M_{F,t}(z) = Y_t(z)^{\phi} \bar{K}^{1-\phi} \left(\alpha_F + \alpha_N \left(\frac{\alpha_F W_t}{\alpha_N P_{F,t}} \right)^{1-\rho} + \alpha_H \left(\frac{\alpha_F P_{H,t}}{\alpha_H P_{F,t}} \right)^{1-\rho} \right)^{\frac{\rho}{1-\rho}} \tag{3.58}$$

Second, the *real* total variable cost function (deflated by consumer prices P_t and denoted by $TC_t(z)$) is derived by substituting the conditional factor demands given in equations (3.56) - (3.58) into equation (3.54) after deflating the total cost by P_t[63]:

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[63] Following Leith and Malley (2007) and Rumler (2007), the total costs of the firm are deflated by the consumer price index P_t by assuming that firms are owned by domestic consumers.

$$TC_t(z) = Y_t(z)^{\phi}\,\overline{K}^{1-\phi}\left[\frac{W_t}{P_t}\left(\alpha_N + \alpha_H\left(\frac{\alpha_N P_{H,t}}{\alpha_H W_t}\right)^{1-\rho} + \alpha_F\left(\frac{\alpha_N P_{F,t}}{\alpha_F W_t}\right)^{1-\rho}\right)^{\frac{\rho}{1-\rho}}\right.$$

$$+\frac{P_{H,t}}{P_t}\left(\alpha_H + \alpha_N\left(\frac{\alpha_H W_t}{\alpha_N P_{H,t}}\right)^{1-\rho} + \alpha_F\left(\frac{\alpha_H P_{F,t}}{\alpha_F P_{H,t}}\right)^{1-\rho}\right)^{\frac{\rho}{1-\rho}}$$

$$\left.+\frac{P_{F,t}}{P_t}\left(\alpha_F + \alpha_N\left(\frac{\alpha_F W_t}{\alpha_N P_{F,t}}\right)^{1-\rho} + \alpha_H\left(\frac{\alpha_F P_{H,t}}{\alpha_H P_{F,t}}\right)^{1-\rho}\right)^{\frac{\rho}{1-\rho}}\right]$$

$$TC_t(z) = Y_t(z)^{\phi}\,\widetilde{MC_t} \tag{3.59}$$

where $\widetilde{MC_t}$ denotes the *non-firm specific* real marginal cost that does not depend on firm's output and is common to all firms.

Third and finally, the *real* marginal cost function (denoted by $MC_t(z)$) is solved by taking the derivative of the real (variable) cost function, $TC_t(z)$, with respect to the firm's output, $Y_t(z)$:

$$MC_t(z) = \frac{\partial TC_t(z)}{\partial Y_t(z)}$$

$$MC_t(z) = \phi Y_t(z)^{\phi-1}\,\widetilde{MC_t} \tag{3.60}$$

It can be seen from equation (3.60) that the real marginal cost of firm z can be decomposed into two components: one that is independent of firm's actions and represented by $\widetilde{MC_t}$, and the other that is specific to each firm and represented by $Y_t(z)$. It is clear from this expression that marginal cost is increasing in firm's output, justifying our previous discussion on increasing marginal costs with fixed input.

The non-firm specific real marginal cost can be further simplified to yield:

$$\widetilde{MC_t} = \overline{K}^{1-\phi}\left(\alpha_N^{\rho}\left(\frac{W_t}{P_t}\right)^{1-\rho} + \alpha_H^{\rho}\left(\frac{P_{H,t}}{P_t}\right)^{1-\rho} + \alpha_F^{\rho}\left(\frac{P_{F,t}}{P_t}\right)^{1-\rho}\right)^{\frac{1}{1-\rho}} \tag{3.61}$$

and after log-linearization we get:

$$\widetilde{mc_t} = \frac{\frac{\overline{W}}{\overline{P}} w_t + \frac{\overline{P}_H}{\overline{P}}\left(\frac{\alpha_H \overline{W}}{\alpha_N \overline{P}_H}\right)^{\rho} p_{H,t} + \frac{\overline{P}_F}{\overline{P}}\left(\frac{\alpha_F \overline{W}}{\alpha_N \overline{P}_F}\right)^{\rho} p_{F,t}}{\frac{\overline{W}}{\overline{P}} + \frac{\overline{P}_H}{\overline{P}}\left(\frac{\alpha_H \overline{W}}{\alpha_N \overline{P}_H}\right)^{\rho} + \frac{\overline{P}_F}{\overline{P}}\left(\frac{\alpha_F \overline{W}}{\alpha_N \overline{P}_F}\right)^{\rho}} - p_t \tag{3.62}$$

where lower case letters denote deviations from steady state and barred variables represent steady state values of the variables.

The expression obtained in equation (3.62) can be rewritten simply in the following form:

$$\widetilde{mc_t} = \frac{\overline{s}_N}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}} w_t + \frac{\overline{s}_{M_H}}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}} p_{H,t} + \frac{\overline{s}_{M_F}}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}} p_{F,t} - p_t \tag{3.63}$$

by noting that

$$\frac{\frac{\overline{W}}{\overline{P}}}{\frac{\overline{W}}{\overline{P}} + \frac{\overline{P}_H}{\overline{P}}\left(\frac{\alpha_H \overline{W}}{\alpha_N \overline{P}_H}\right)^{\rho} + \frac{\overline{P}_F}{\overline{P}}\left(\frac{\alpha_F \overline{W}}{\alpha_N \overline{P}_F}\right)^{\rho}} = \frac{\frac{\overline{W}}{\overline{P}}}{\frac{\overline{W}}{\overline{P}} + \frac{\overline{P}_H \overline{M}_H}{\overline{P}\overline{N}} + \frac{\overline{P}_F \overline{M}_F}{\overline{P}\overline{N}}}$$

$$= \frac{\bar{W}\bar{N}}{\bar{W}\bar{N} + \bar{P}_H\bar{M}_H + \bar{P}_F\bar{M}_F} = \frac{\dfrac{\bar{W}\bar{N}}{\bar{P}_H\bar{\tilde{Y}}}}{\dfrac{\bar{W}\bar{N}}{\bar{P}_H\bar{\tilde{Y}}} + \dfrac{\bar{P}_H\bar{M}_H}{\bar{P}_H\bar{\tilde{Y}}} + \dfrac{\bar{P}_F\bar{M}_F}{\bar{P}_H\bar{\tilde{Y}}}} = \frac{\bar{s}_N}{\bar{s}_N + \bar{s}_{M_H} + \bar{s}_{M_F}} \tag{3.64}$$

$$\frac{\dfrac{\bar{P}_H}{\bar{P}}\left(\dfrac{\alpha_H\bar{W}}{\alpha_N\bar{P}_H}\right)^{\rho}}{\dfrac{\bar{W}}{\bar{P}} + \dfrac{\bar{P}_H}{\bar{P}}\left(\dfrac{\alpha_H\bar{W}}{\alpha_N\bar{P}_H}\right)^{\rho} + \dfrac{\bar{P}_F}{\bar{P}}\left(\dfrac{\alpha_F\bar{W}}{\alpha_N\bar{P}_F}\right)^{\rho}} = \frac{\dfrac{\bar{P}_H\bar{M}_H}{\bar{P}\bar{N}}}{\dfrac{\bar{W}}{\bar{P}} + \dfrac{\bar{P}_H\bar{M}_H}{\bar{P}\bar{N}} + \dfrac{\bar{P}_F\bar{M}_F}{\bar{P}\bar{N}}}$$

$$= \frac{\bar{P}_H\bar{M}_H}{\bar{W}\bar{N} + \bar{P}_H\bar{M}_H + \bar{P}_F\bar{M}_F} = \frac{\dfrac{\bar{P}_H\bar{M}_H}{\bar{P}_H\bar{\tilde{Y}}}}{\dfrac{\bar{W}}{\bar{P}_H\bar{\tilde{Y}}} + \dfrac{\bar{P}_H\bar{M}_H}{\bar{P}_H\bar{\tilde{Y}}} + \dfrac{\bar{P}_F\bar{M}_F}{\bar{P}_H\bar{\tilde{Y}}}} = \frac{\bar{s}_{M_H}}{\bar{s}_N + \bar{s}_{M_H} + \bar{s}_{M_F}} \tag{3.65}$$

and

$$\frac{\dfrac{\bar{P}_F}{\bar{P}}\left(\dfrac{\alpha_F\bar{W}}{\alpha_N\bar{P}_F}\right)^{\rho}}{\dfrac{\bar{W}}{\bar{P}} + \dfrac{\bar{P}_H}{\bar{P}}\left(\dfrac{\alpha_H\bar{W}}{\alpha_N\bar{P}_H}\right)^{\rho} + \dfrac{\bar{P}_F}{\bar{P}}\left(\dfrac{\alpha_F\bar{W}}{\alpha_N\bar{P}_F}\right)^{\rho}} = \frac{\dfrac{\bar{P}_F\bar{M}_F}{\bar{P}\bar{N}}}{\dfrac{\bar{W}}{\bar{P}} + \dfrac{\bar{P}_H\bar{M}_H}{\bar{P}\bar{N}} + \dfrac{\bar{P}_F\bar{M}_F}{\bar{P}\bar{N}}}$$

$$= \frac{\bar{P}_F\bar{M}_F}{\bar{W}\bar{N} + \bar{P}_H\bar{M}_H + \bar{P}_F\bar{M}_F} = \frac{\dfrac{\bar{P}_F\bar{M}_F}{\bar{P}_H\bar{\tilde{Y}}}}{\dfrac{\bar{W}}{\bar{P}_H\bar{\tilde{Y}}} + \dfrac{\bar{P}_H\bar{M}_H}{\bar{P}_H\bar{\tilde{Y}}} + \dfrac{\bar{P}_F\bar{M}_F}{\bar{P}_H\bar{\tilde{Y}}}} = \frac{\bar{s}_{M_F}}{\bar{s}_N + \bar{s}_{M_H} + \bar{s}_{M_F}} \tag{3.66}$$

where $\bar{\tilde{Y}}$ represents the steady state value of real Gross Domestic Product (GDP). The distinction between aggregate output (Y) and real GDP ($\tilde{Y}$) will become clear in subsection III.B.3.2.

In deriving equations (3.64) – (3.66), we used the cost-minimizing combinations given by:

$$\frac{M_{F,t}}{N_t} = \left(\frac{\alpha_F W_t}{\alpha_N P_{F,t}} \right)^{\rho} \tag{3.67}$$

and

$$\frac{M_{H,t}}{N_t} = \left(\frac{\alpha_H W_t}{\alpha_N P_{H,t}} \right)^{\rho} \tag{3.68}$$

Also note that in equations (3.64) – (3.66) $\overline{s}_N$, $\overline{s}_{M_H}$ and $\overline{s}_{M_F}$ are used to denote the shares of labor, domestic intermediate goods and imported intermediate goods in GDP, respectively.

III.B.2 Goods Market Equilibrium

The goods market equilibrium condition holds for the *z*-th domestic product and can be expressed in the following form:

$$Y_t(z) = C_{H,t}(z) + M_{H,t}(z) + C^*_{H,t}(z) + M^*_{H,t}(z) \tag{3.69}$$

where the domestic output of firm *z* ($Y_t(z)$) given in equation (3.69) amounts to the demand for its consumption good at home and abroad, $C_{H,t}(z)$ and $C^*_{H,t}(z)$, as well as for its output employed as intermediate input by domestic and foreign firms, $M_{H,t}(z)$ and $M^*_{H,t}(z)$.

The home and imported intermediate good indices used in home production are, again, given by CES aggregators of the quantities used of each type of good *z*:

$$M_{H,t} = \left[\int_0^1 M_{H,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.70}$$

and

$$M_{F,t} = \left[\int_0^1 M_{F,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.71}$$

The two-step optimization problem solved by domestic and foreign consumers in subsection III.A.1 is solved here also by the domestic and foreign firms. First, each input demanding firm's spending must be allocated optimally between home and foreign produced intermediate goods at each point in time, taking as given the overall level of expenditure on the composite intermediate good, M_t. Second, the firm's home and imported intermediate spending must be optimally allocated separately across differentiated intermediate goods within each category at each point in time, taking as given the overall level of expenditure on each category (i.e. expenditure on the domestically produced intermediate good index, $M_{H,t}$, and the foreign produced intermediate good index, $M_{F,t}$).

The set of optimality conditions obtained for the domestic firms are analogous to those that result from the domestic consumer's problem:

$$M_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} M_t \tag{3.72}$$

$$M_{F,t} = \gamma\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} M_t \tag{3.73}$$

$$M_{H,t}(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\kappa} M_{H,t} \tag{3.74}$$

$$M_{F,t}(z)=\left(\frac{P_{F,t}(z)}{P_{F,t}}\right)^{-\kappa} M_{F,t} \tag{3.75}$$

for all $z \in (0,1)$, where

$$M_t=\left[(1-\gamma)^{1/\eta} M_{H,t}^{\frac{\eta-1}{\eta}}+\gamma^{1/\eta} M_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{3.76}$$

represents a composite intermediate goods index that is comprised of the index of domestically produced intermediate goods ($M_{H,t}$) and index of foreign produced (i.e., imported) intermediate goods ($M_{F,t}$). Since each domestic firm z sells his product to both consumers as final good and to firms as intermediate good, the price indices associated with intermediate production correspond to those associated with final good production. That is, P_t, $P_{H,t}$ and $P_{F,t}$ in equations (3.72) – (3.75) are given by equations (3.10), (3.16) and (3.20), respectively.

The set of optimality conditions obtained for the input demanding firms in the ROW are analogous to those that result from the foreign consumer's problem:

$$M_{H,t}^{*}=\gamma^{*}\left(\frac{P_{H,t}^{*}}{P_t^{*}}\right)^{-\eta} M_t^{*}=\gamma^{*}\left(\frac{E_t P_{H,t}}{P_t^{*}}\right)^{-\eta} M_t^{*} \tag{3.77}$$

$$M_{F,t}^{*}=(1-\gamma^{*})\left(\frac{P_{F,t}^{*}}{P_t^{*}}\right)^{-\eta} M_t^{*} \tag{3.78}$$

$$M_{H,t}^{*}(z)=\left(\frac{P_{H,t}^{*}(z)}{P_{H,t}^{*}}\right)^{-\kappa} M_{H,t}^{*}=\left(\frac{E_t P_{H,t}(z)}{E_t P_{H,t}}\right)^{-\kappa} M_{H,t}^{*}=\left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\kappa} M_{H,t}^{*} \tag{3.79}$$

$$M^*_{F,t}(z) = \left(\frac{P^*_{F,t}(z)}{P^*_{F,t}} \right)^{-\kappa} M^*_{F,t} \tag{3.80}$$

for all $z \in (0,1)$, where

$$M^*_t = \left[(1-\gamma^*)^{1/\eta} M^{*\,\frac{\eta-1}{\eta}}_{F,t} + (\gamma^*)^{1/\eta} M^{*\,\frac{\eta-1}{\eta}}_{H,t} \right]^{\frac{\eta}{\eta-1}} \tag{3.81}$$

$$M^*_{H,t} = \left[\int_0^1 M^*_{H,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.82}$$

and

$$M^*_{F,t} = \left[\int_0^1 M^*_{F,t}(z)^{\frac{\kappa-1}{\kappa}} dz \right]^{\frac{\kappa}{\kappa-1}} \tag{3.83}$$

In equations (3.77) – (3.83); $M^*_t, M^*_{H,t}, M^*_{F,t}, M^*_{H,t}(z)$ and $M^*_{F,t}(z)$ denote the composite intermediate good index of the ROW, the index of domestically produced intermediate goods used by firms in the ROW, the index of foreign produced intermediate goods used by firms in the ROW, the domestically produced intermediate good z used by firms in the ROW and the foreign produced intermediate good z used by firms in the ROW, respectively.

Likewise the case of domestic firms, P^*_t, $P^*_{H,t}$ and $P^*_{F,t}$ are given by equations (3.32), (3.33) and (3.34), respectively

As discussed in subsection III.A.1, our treatment of the rest of the world as a (approximately) closed economy (with goods produced in the small open economy representing a negligible fraction of the worlds consumption basket) implies that we focus on the limiting case $\gamma^* \to 0$ where $M^*_{H,t} \to 0$ and $M^*_{F,t} \to M^*_t$.

After plugging equations (3.15), (3.27), (3.74) and (3.79) into the goods market equilibrium condition (3.69) we obtain:

$$Y_t(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\kappa} \left(C_{H,t} + M_{H,t} + C^*_{H,t} + M^*_{H,t} \right) \tag{3.84}$$

However, since we focus on the case where $C^*_{H,t} \to 0$ and $M^*_{H,t} \to 0$, the expression given in equation (84) simplifies to:

$$Y_t(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\kappa} \left(C_{H,t} + M_{H,t} \right) \tag{3.85}$$

According to equation (3.85), the output of firm *z* depends on the price charged by firm *z* relative to the other domestically produced goods and the total demand that domestic consumers and producers allocate to domestic goods.

To arrive at the goods market equilibrium condition in aggregate terms, first we use equations (11) and (72) to eliminate $C_{H,t}$ and $M_{H,t}$ in equation (3.85):

$$Y_t(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\kappa} \left((1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} M_t \right)$$

$$Y_t(z)^{\frac{(\kappa-1)}{\kappa}} = \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-(\kappa-1)} \left((1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} M_t \right)^{\frac{(\kappa-1)}{\kappa}} \tag{3.86}$$

and then substitute equation (3.52) for aggregate output into the previous result to obtain:

$$Y_t = \left[\int_0^1 \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-(\kappa-1)} \left((1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} M_t \right)^{\frac{(\kappa-1)}{\kappa}} dz \right]^{\frac{\kappa}{(\kappa-1)}}$$

$$Y_t^{\frac{(\kappa-1)}{\kappa}} = \int_0^1 \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-(\kappa-1)} \left((1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} M_t \right)^{\frac{(\kappa-1)}{\kappa}} dz$$

$$Y_t^{\frac{(\kappa-1)}{\kappa}} = \left((1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} M_t \right)^{\frac{(\kappa-1)}{\kappa}} \int_0^1 \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{(1-\kappa)} dz$$

$$Y_t^{\frac{(\kappa-1)}{\kappa}} = \left((1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} M_t \right)^{\frac{(\kappa-1)}{\kappa}} \left(\frac{1}{P_{H,t}} \right)^{(1-\kappa)} \int_0^1 P_{H,t}(z)^{1-\kappa} dz$$

$$Y_t^{\frac{(\kappa-1)}{\kappa}} = \left((1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + (1-\gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} M_t \right)^{\frac{(\kappa-1)}{\kappa}} \left(\frac{1}{P_{H,t}} \right)^{(1-\kappa)} P_{H,t}{}^{1-\kappa}$$

$$Y_t = C_{H,t} + M_{H,t} \tag{3.87}$$

In the last step we used the optimal allocation functions (3.11) and (3.72).

Equation (3.87), which is the goods market equilibrium condition for the domestic economy, states that domestic product (Y_t) amounts to the domestic final ($C_{H,t}$) and intermediate ($M_{H,t}$) usage of the home produced goods.

III.B.3 Price Setting Behaviour

We assume a Calvo (1983) type of price setting, in which every period every firm is able to adjust its price with a fixed probability of ($1-\theta$). Thus, each period a measure *(1-θ)* of producers reset their prices, while a fraction θ keep their prices fixed (i.e. unchanged).

The probability of price adjustment is given exogenously and is independent of the length of time since the last price was set and of what the particular good's current price may be[64]. By making this price adjustment probability independent of a firm's pricing history, the Calvo type rules facilitates the aggregation problem and therefore are widely used in the literature[65]. Furthermore, this probability is constant across firms and the expected time a price remains fixed (i.e. the expected time between two price adjustments) is given by *1/(1-θ)*. Thus, for example if θ equals 0.75 in a quarterly model, then 25% of all firms change their prices every quarter and prices are fixed on average for a year (1/(1-0.75) = 4 quarters). Therefore, θ is a key parameter in our model. It measures the *degree of price stickiness* in the economy.

Let $P_{H,t}^{Fixed}$ denote the index of domestic prices that are kept *fixed* in period *t* and $P_{H,t}^{N}$ the index of domestic prices that are allowed to adjust (*newly* set in period *t*). The θ fraction of prices that are kept fixed in period *t* are subset of prices charged in period *(t-1)* and therefore are a combination of prices that were newly set in period *(t-1)* and held fixed in period *(t-1)*. Going thus backwards with repeated substitution, it is possible to write $P_{H,t-1}^{Fixed} = P_{H,t-1}$. Then the aggregate home price index (16) in period *t* satisfies

$$P_{H,t}^{1-\kappa} = \int_{z=0}^{1} P_{H,t}(z)^{1-\kappa}\,dz = \theta \int_{z=0}^{1} P_{H,t-1}(z)^{1-\kappa}\,dz + (1-\theta)\int_{z=0}^{1} P_{H,t}^{N}(z)^{1-\kappa}\,dz$$

[64] This type of a constraint on price adjustment is called *'time dependent pricing'*. The models in which the timing of price adjustments are endogeneized are called *'state dependent'*. We abstract from state dependent models. Although one may think that state dependent timing models do have better micro foundations than their time dependent counterparts, Woodford (2003, p. 142) argues that this is not so obvious. Furthermore, Woodford warns that advantages of endogeneizing prices may far more outweigh their disadvantages in terms of the diffuculty in deriving the necessary equations.

[65] For the applications of Calvo type price setting rules see Galí and Gertler (1999) and Woodford (2003, p. 142) and the references therein.

so that

$$P_{H,t} = \left[\theta \left(P_{H,t-1} \right)^{1-\kappa} + (1-\theta) \left(P_{H,t}^{N} \right)^{1-\kappa} \right]^{\frac{1}{1-\kappa}} \tag{3.88}$$

where the index of domestic prices newly set in period t is given by

$$P_{H,t}^{N} = \left(\int_{z=0}^{1} P_{H,t}^{N}(z)^{1-\kappa} dz \right)^{\frac{1}{1-\kappa}}.$$

Once equation (3.88) is log-linearized, the aggregate home price level can be shown to evolve according to the following rule in log-deviations:

$$p_{H,t} = \theta p_{H,t-1} + (1-\theta) p_{H,t}^{N} \tag{3.89}$$

We also assume that within the group of Calvo price setters (ones that are allowed to change their price) some follow a *backward looking rule of thumb* updating their prices with past inflation while the rest sets it optimally. We assume that only *(1-ω)* of the firms that are able to change their prices in period *t*, set their prices optimally by taking into account the fact that a price set in period *t* can still be charged after *k* periods. These firms are called *forward looking*. The remaining *ω* of firms set their prices according to a backward looking rule of thumb even in the case that they receive the signal to adjust their price. Thus, every period, the firms that are able to reset their prices are divided into two groups: forward looking firms that set their prices optimally taking the demand and cost conditions into account and the backward looking ones that do not set their prices optimally and follow a simple rule of thumb. If, for example, ω=0.3, then 30% of all firms follow a backward looking rule of thumb in setting their prices. Therefore, ω is another key parameter in our model. It measures the *degree of backwardness* in price setting and indicates the *degree of intrinsic inflation inertia*[66].

Denote the *optimal* price set by a *forward* looking domestic firm by $P_{H,t}^{f}$ and the price set by a *backward* looking domestic firm by $P_{H,t}^{b}$. As each forward looking firm $z \in (0,1)$ that chooses a new price for its good in period *t* faces exactly the same decision problem (since they are identical except for the differentiated product they produce), the optimal price $P_{H,t}^{f}(z)$ is the same for all of them, and so in equilibrium all forward looking prices that are chosen in period *t* have the same common value $P_{H,t}^{f}$. The same is true for the backward looking firm. Each backward looking domestic firm sets its price equal to the average of the newly set prices in the previous period, $P_{H,t-1}^{N}$, updated by the previous period inflation rate, $\pi_{H,t-1}$. Then the index of domestic prices newly set in period, $P_{H,t}^{N}$, can be expressed as

$$\left(P_{H,t}^{N}\right)^{1-\kappa} = \int_{z=0}^{1} P_{H,t}^{N}(z)^{1-\kappa} dz = (1-\omega)\left(P_{H,t}^{f}\right)^{1-\kappa} + \omega\left(P_{H,t}^{b}\right)^{1-\kappa}$$

$$P_{H,t}^{N} = \left((1-\omega)\left(P_{H,t}^{f}\right)^{1-\kappa} + \omega\left(P_{H,t}^{b}\right)^{1-\kappa}\right)^{\frac{1}{1-\kappa}}$$

so that after log-linearizing

$$p_{H,t}^{N} = (1-\omega)p_{H,t}^{f} + \omega p_{H,t}^{b} \tag{3.90}$$

As explained above the backward looking price is assumed to be given by:

$$P_{H,t}^{b} = P_{H,t-1}^{N}(1+\pi_{H,t-1}) \tag{3.91}$$

[66] The details will be covered in section D.

or in log-deviations as:

$$p^b_{H,t} = p^N_{H,t-1} + \pi_{H,t-1} \tag{3.92}$$

where $\pi_{H,t} = p_{H,t} - p_{H,t-1}$.

The formulation given in (3.91) follows from Galí and Gertler (1999), Galí et al. (2001), Rumler (2007) and Leith and Malley (2007). This backward looking rule of thumb, although may seem unrealistic at the first sight, is specified by Galí and Gertler (1999) to have two important features: First, the rule is consistent with optimal behaviour; second, the backward looking price only depends on information up to period *(t-1)*. Galí and Gertler (1999) also assume that the firm is unable to tell whether any individual competitor is backward looking or forward looking. All these assumptions lead to the specification given in equation (3.91).

III.B.3.1 Derivation of the hybrid NKPC equation

To derive the hybrid NKPC equation for domestic inflation, first we must solve the optimization problem of the *forward* looking domestic firm which is able to reset its price at period *t* by, maximizing his future discounted profits subject to Calvo type pricing. Then, the solution to this problem will be used together with equations characterizing the backward-looking rule of thumb behavior and a hybrid NKPC characterizing domestic producer inflation will be derived.

Each domestic firm chooses the optimal reset price at *t*, which we have denoted by $P^f_{H,t}(z)$, to maximize the *expected discounted real profits* over the course of the contract.

The *real* profit of firm *z* at period *t* can be written as[67]:

$$\frac{P_{H,t}^{f}(z)Y_{t}(z)}{P_{t}}-\left(\frac{W_{t}N_{t}(z)-P_{F,t}M_{F,t}(z)-P_{H,t}M_{H,t}(z)}{P_{t}}\right) \tag{3.93}$$

and after substituting equation (3.59) for the real variable total cost in the parenthesis in the following form:

$$\frac{P_{H,t}^{f}(z)}{P_{t}}Y_{t}(z)-Y_{t}(z)^{\phi}\widetilde{MC}_{t} \tag{3.94}$$

Since goods market should be at equilibrium, we can substitute Y_t from equation (3.85) into (3.94), and obtain the following real profit function for firm *z*:

$$\left(\frac{P_{H,t}^{f}(z)}{P_{t}}\right)\left(\frac{P_{H,t}^{f}(z)}{P_{H,t}}\right)^{-\kappa}\left(C_{H,t}+M_{H,t}\right)-\left(\frac{P_{H,t}^{f}(z)}{P_{H,t}}\right)^{-\phi\kappa}\left(C_{H,t}+M_{H,t}\right)^{\phi}\widetilde{MC}_{t} \tag{3.95}$$

As all forward looking prices that are chosen in period *t* have the same common value $P_{H,t}^{f}$ for all firms, the above equation to be rewritten solely in terms of aggregates as:

$$\left(\frac{P_{H,t}^{f}}{P_{t}}\right)\left(\frac{P_{H,t}^{f}}{P_{H,t}}\right)^{-\kappa}\left(C_{H,t}+M_{H,t}\right)-\left(\frac{P_{H,t}^{f}}{P_{H,t}}\right)^{-\phi\kappa}\left(C_{H,t}+M_{H,t}\right)^{\phi}\widetilde{MC}_{t} \tag{3.96}$$

where $P_{H,t}^{f}$ now denotes the newly set optimal price by all forward looking firms $z\in(0,1)$.

---

[67] Following Leith and Malley (2007) and Rumler (2007) we ignore the fixed costs of utilizing the capital stock in formulating the firm's problem and we assume that all shocks are sufficiently small that firms continue to earn positive profits at all points in time.

Equation (3.96) gives the real profits of the firm in only one period, period *t*. To solve the firm's optimization problem, we need to write the expected discounted real profits over the whole course of the contract. Thus, each firm will maximize:

$$\left(\frac{P^f_{H,t}}{P_t}\right)\left(\frac{P^f_{H,t}}{P_{H,t}}\right)^{-\kappa} Y_t - \left(\frac{P^f_{H,t}}{P_{H,t}}\right)^{-\phi\kappa} Y_t^{\phi}\widetilde{MC_t}$$

$$+E_t\sum_{s=1}^{\infty}\beta^s\theta^s\left[\left(\frac{P^f_{H,t}}{P_{t+s}}\right)\left(\frac{P^f_{H,t}}{P_{H,t+s}}\right)^{-\kappa} Y_{t+s} - \left(\frac{P^f_{H,t}}{P_{H,t+s}}\right)^{-\phi\kappa} Y_{t+s}{}^{\phi}\widetilde{MC_{t+s}}\right] \qquad (3.97)$$

where θ^s is the probability that the forward looking price $P^f_{H,t}(z)$ set for the domestic good *z* at time *t* still holds *s* periods ahead and $Y_t = C_{H,t} + M_{H,t}$ is the aggregate domestic output supplying domestic final and intermediate goods demand obtained from the goods market equilibrium condition (3.76). In (3.97) the firms are assumed to discount future profits using a subjective discount factor that is equal on average to β, where $0<\beta<1$[68].

Differentiating equation (3.97) with respect to $P^f_{H,t}$ will result in the following *first order condition* for the *firm's maximization problem*:

$$\left(P^f_{H,t}\right)^{1+\kappa(\phi-1)} = \frac{\kappa\phi\left(P_{H,t}\right)^{\kappa\phi} Y_t^{\phi}\widetilde{MC_t} + E_t\sum_{s=1}^{\infty}(\beta\theta)^s\left[\kappa\phi\left(P_{H,t+s}\right)^{\kappa\phi} Y_{t+s}{}^{\phi}\widetilde{MC_{t+s}}\right]}{(\kappa-1)P^{\kappa}_{H,t}P_t^{-1}Y_t + E_t\sum_{s=1}^{\infty}(\beta\theta)^s\left[(\kappa-1)P^{\kappa}_{H,t+s}P^{-1}_{t+s}Y_{t+s}\right]} \qquad (3.98)$$

and after log-linearization:

[68] It is not necessary for the derivations that the factor β coincide with the utility discount factor of the representative household.

$$p_{H,t}^f = \left(\frac{1-\theta\beta}{1+\kappa(\phi-1)} \right) E_t \sum_{s=0}^{\infty} (\beta\theta)^s \left[\widetilde{mc}_{t+s} + (\phi-1) y_{t+s} + p_{t+s} + \kappa(\phi-1) p_{H,t+s} \right] \quad (3.99)$$

where again small case letters denote the percentage deviations of a variable from its respective steady-state value. Equation (3.99) shows the rule (in log-deviations) according to which the domestic optimizing firm will set its price.

Using equation (3.99) together with the ones characterizing the backward-looking rule of thumb behaviour - (3.89), (3.90) and (3.92) - the domestic price level, $p_{H,t}$, will be written solely in terms of its own leads and lags, $\widetilde{mc}_t$, y_t and p_t.

First, utilizing equation (3.99), write the expectation of $p_{H,t+1}^f$ at *t*, $E_t p_{H,t+1}^f$, in the following form:

$$E_t p_{H,t+1}^f = \left(\frac{1-\theta\beta}{1+\kappa(\phi-1)} \right) E_t \sum_{s=0}^{\infty} (\beta\theta)^s \left[\widetilde{mc}_{t+s+1} + (\phi-1) y_{t+s+1} + p_{t+s+1} \right.$$

$$\left. + \kappa(\phi-1) p_{H,t+s+1} \right] \quad (3.100)$$

or

$$E_t p_{H,t+1}^f = \left(\frac{1-\theta\beta}{1+\kappa(\phi-1)} \right) E_t \sum_{s=1}^{\infty} (\beta\theta)^{s-1} \left[\widetilde{mc}_{t+s} + (\phi-1) y_{t+s} + p_{t+s} + \kappa(\phi-1) p_{H,t+s} \right]$$

(3.101)

where again expectations are conditional upon the information set available at time *t* (Ω_t), i.e. $E_t p_{H,t+1}^f = E\left\{ p_{H,t+1}^f \middle| \Omega_t \right\}$.

Second, rewrite equation (3.99) as:

$$p_{H,t}^{f} = \left(\frac{1-\theta\beta}{1+\kappa(\phi-1)}\right)\left[\widetilde{mc}_t + (\phi-1)y_t + p_t + \kappa(\phi-1)p_{H,t}\right]$$

$$+\left(\frac{1-\theta\beta}{1+\kappa(\phi-1)}\right)E_t\sum_{s=1}^{\infty}\left(\beta\theta\right)^{s}\left[\widetilde{mc}_{t+s} + (\phi-1)y_{t+s} + p_{t+s} + \kappa(\phi-1)p_{H,t+s}\right]$$

$$p_{H,t}^{f} = \left(\frac{1-\theta\beta}{1+\kappa(\phi-1)}\right)\left[\widetilde{mc}_t + (\phi-1)y_t + p_t + \kappa(\phi-1)p_{H,t}\right]$$

$$+\left(\frac{1-\theta\beta}{1+\kappa(\phi-1)}\right)\left(\beta\theta\right)E_t\sum_{s=1}^{\infty}\left(\beta\theta\right)^{s-1}\left[\widetilde{mc}_{t+s} + (\phi-1)y_{t+s}\right.$$

$$\left. + p_{t+s} + \kappa(\phi-1)p_{H,t+s}\right] \tag{3.102}$$

and after substituting equation (3.101) in the following form:

$$p_{H,t}^{f} = \left(\frac{1-\theta\beta}{1+\kappa(\phi-1)}\right)\left[\widetilde{mc}_t + (\phi-1)y_t + p_t + \kappa(\phi-1)p_{H,t}\right] + \beta\theta E_t p_{H,t+1}^{f} \tag{3.103}$$

Third, from equation (3.89) solve for the log-linearized index of *newly* set domestic prices, $p_{H,t}^{N}$, in the following form:

$$p_{H,t}^{N} = \frac{1}{1-\theta}\left(p_{H,t} - \theta p_{H,t-1}\right) \tag{3.104}$$

and substitute this into equation (3.90) to obtain:

$$\frac{1}{1-\theta}\left(p_{H,t} - \theta p_{H,t-1}\right) = (1-\omega)p_{H,t}^{f} + \omega p_{H,t}^{b} \tag{3.105}$$

Using equations (3.92) and (3.104) reformulate equation (3.105) as follows:

$$\frac{1}{1-\theta}\left(p_{H,t}-\theta p_{H,t-1}\right)=(1-\omega)p_{H,t}^{f}+\frac{\omega}{1-\theta}p_{H,t-1}-\frac{\omega\theta}{1-\theta}p_{H,t-2}+\omega\pi_{H,t-1} \tag{3.106}$$

As a fourth step, solve for the log-linearized *optimal* price set by a *forward* looking domestic firm, $p_{H,t}^{f}$, from equation (3.90) to obtain:

$$p_{H,t}^{f}=\frac{1}{1-\omega}(p_{H,t}^{N}-\omega p_{H,t}^{b}) \tag{3.107}$$

and $$E_t p_{H,t+1}^{f}=\frac{1}{1-\omega}(E_t p_{H,t+1}^{N}-\omega E_t p_{H,t+1}^{b}) \tag{3.108}$$

Then substitute equations (3.92) and (3.104) into equation (3.108):

$$E_t p_{H,t+1}^{f}=\frac{1}{1-\omega}\left[\frac{1}{1-\theta}\left(E_t p_{H,t+1}-\theta p_{H,t}\right)-\omega\left(\frac{1}{1-\theta}\left(p_{H,t}-\theta p_{H,t-1}\right)+\pi_{H,t}\right)\right]$$

$$E_t p_{H,t+1}^{f}=\frac{1}{1-\omega}\left[\frac{1}{1-\theta}E_t p_{H,t+1}-\frac{\theta}{1-\theta}p_{H,t}-\frac{\omega}{1-\theta}p_{H,t}+\frac{\omega\theta}{1-\theta}p_{H,t-1}-\omega\pi_{H,t}\right]$$

$$E_t p_{H,t+1}^{f}=\frac{1}{1-\omega}\frac{1}{1-\theta}E_t p_{H,t+1}-\frac{1}{1-\omega}\frac{\theta}{1-\theta}p_{H,t}-\frac{1}{1-\omega}\frac{\omega}{1-\theta}p_{H,t}$$

$$+\frac{1}{1-\omega}\frac{\omega\theta}{1-\theta}p_{H,t-1}-\frac{\omega}{1-\omega}\pi_{H,t} \tag{3.109}$$

and use equation (3.109) together with equation (3.103) to obtain:

$$p^f_{H,t} = \left(\frac{1-\theta\beta}{1+\kappa(\phi-1)} \right) \left[\widetilde{mc}_t + (\phi-1)y_t + p_t + \kappa(\phi-1)p_{H,t} \right]$$

$$+\left(\beta\theta\right)\frac{1}{1-\omega}\frac{1}{1-\theta}E_t p_{H,t+1} - \left(\beta\theta\right)\frac{1}{1-\omega}\frac{\theta}{1-\theta}p_{H,t} - \left(\beta\theta\right)\frac{1}{1-\omega}\frac{\omega}{1-\theta}p_{H,t}$$

$$+\left(\beta\theta\right)\frac{1}{1-\omega}\frac{\omega\theta}{1-\theta}p_{H,t-1} - \left(\beta\theta\right)\frac{\omega}{1-\omega}\pi_{H,t}$$

(3.110)

Finally, substitute equation (3.110) into equation (3.106) to obtain:

$$\frac{1}{1-\theta}p_{H,t} - \frac{\theta}{1-\theta}p_{H,t-1} = \frac{(1-\theta\beta)(1-\omega)}{(1+\kappa(\phi-1))}\widetilde{mc}_t + \frac{(1-\theta\beta)(\phi-1)(1-\omega)}{(1+\kappa(\phi-1))}y_t$$

$$+\frac{(1-\theta\beta)(1-\omega)}{(1+\kappa(\phi-1))}p_t + \frac{(1-\theta\beta)\kappa(\phi-1)(1-\omega)}{(1+\kappa(\phi-1))}p_{H,t}$$

$$+\left(\beta\theta\right)\frac{1}{1-\theta}E_t p_{H,t+1} - \left(\beta\theta\right)\frac{\theta}{1-\theta}p_{H,t}$$

$$-\left(\beta\theta\right)\frac{\omega}{1-\theta}p_{H,t} + \left(\beta\theta\right)\frac{\omega\theta}{1-\theta}p_{H,t-1}$$

$$-\left(\beta\theta\right)\omega\pi_{H,t} + \frac{\omega}{1-\theta}p_{H,t-1} - \frac{\omega\theta}{1-\theta}p_{H,t-2} + \omega\pi_{H,t-1}$$

(3.111)

which is the equation for $p_{H,t}$ that is written solely in terms of its own leads and lags, $\widetilde{mc}_t$, y_t and p_t.

Gathering terms and after some simplifications, equation (3.111) can be reformulated as the following *rule for the development of the domestic inflation*:

$$\pi_{H,t} = \frac{\beta\theta}{\Delta} E_t \pi_{H,t+1} + \frac{\omega}{\Delta}\pi_{H,t-1} + \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left(\widetilde{mc_t} + (\phi-1)y_t + p_t - p_{H,t}\right) \quad (3.112)$$

where $\Delta = \theta + \omega(1-\theta(1-\beta))$ and $E_t\{\pi_{t+1}\} = E\{\pi_{t+1} | \Omega_t\}$. Utilizing the log-linearized version of equation (3.60), the first two terms in the square brackets can be written as *real marginal cost*. The last two terms in the square brackets arise from assuming that firms are owned by domestic consumers and therefore deflating the nominal variables by the consumer price index, P_t, rather than the domestic price index, $P_{H,t}$. If the profits or costs were deflated by the domestic price index, $P_{H,t}$, the last two terms in the square brackets would disappear and we would end up with only the real marginal cost term. Therefore, without loss of generality, equation (3.112) could also be referred to as:

$$\pi_{H,t} = \frac{\beta\theta}{\Delta} E_t \pi_{H,t+1} + \frac{\omega}{\Delta}\pi_{H,t-1} + \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta} mc_t \quad (3.113)$$

where mc_t denotes the *real marginal cost* in log-deviations.

Equation (3.112) or (3.113) is called the hybrid NKPC characterizing domestic inflation where the domestic inflation dynamics is not only backward looking but also forward looking. If all firms in the economy have a chance for adjusting their prices ($\theta \rightarrow 0$) but all firms are backward looking so that in reality none is able to choose an optimal new price ($\omega \rightarrow 1$), the Phillips Curve is purely backward–looking with adaptive expectations. On the other hand, if all firms in the economy are forward looking and therefore have a chance for reoptimizing their prices ($\omega \rightarrow 0$), domestic inflation is purely forward looking and disinflationary policy would be fully costless[69]. The domestic inflation is

[69] This is called the *pure forward looking specification* of the NKPC where inflation at time *t* is a function of the expected inflation at time *t* and real marginal costs at time *t*, which is a measure of the real economic activity. In the traditional Phillips curve literature, inflation is also a function of the real economic activity. The striking difference is the forward looking nature of inflation emphasized by the NKPC literature when compared to the traditional Phillips curve that is backward looking. It is then the $E_t\pi_{t+1}$ term that matters, rather than the

always influenced by the marginal costs of firms, except in the first extreme case.

Since inflation is the result of the aggregate pricing decisions in the economy, to arrive at an equation describing inflation dynamics, we need an underlying theory that describes the price setting decisions of the firms in the economy. To model price setting and analyze the factors that derive the optimal pricing decision, firms should be allowed to have some degree of market power in the markets that they sell their products. Without firms having some degree of market power over their products, talking about price setting on behalf of firms would sound implausible. Therefore, firms are modeled as producing differentiated products and selling them at monopolistically competitive markets. Thus, the equilibrium prices set with a markup above marginal cost in a sense rationalizes the price adjustment constraint that the firms face. Since firms are already charging a price greater than their marginal cost, they may not change their price constantly for any change in demand that they face (i.e., the ones that could not adjust its price immediately as a result of the price adjustment constraint they face). This interaction between price setting, markups, marginal costs, and inflation is crucial in the theory underlying the NKPC literature.

III.B.3.2 Derivation of the empirical hybrid NKPC equation

Now we will transform the NKPC equation (3.112) into a form appropriate for estimation. To do so, first, substitute equation (3.63) for the non-firm specific real marginal cost term $\widetilde{mc_t}$, and rewrite equation (3.112) in the following form:

$E_{t-1}\pi_t$ term that is generally assumed equal to π_{t-1} in the traditional literature.

$$\pi_{H,t} = \frac{\beta\theta}{\Delta} E_t \pi_{H,t+1} + \frac{\omega}{\Delta}\pi_{H,t-1} + \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left(\frac{\bar{s}_N}{\bar{s}_N + \bar{s}_{M_H} + \bar{s}_{M_F}} w_t \right.$$

$$\left. + \frac{\bar{s}_{M_H}}{\bar{s}_N + \bar{s}_{M_H} + \bar{s}_{M_F}} p_{H,t} + \frac{\bar{s}_{M_F}}{\bar{s}_N + \bar{s}_{M_H} + \bar{s}_{M_F}} p_{F,t} + (\phi - 1) y_t - p_{H,t} \right) \tag{3.114}$$

Due to the use of intermediate inputs in the production process, the definition of aggregate output (y_t) appearing in equation (3.114) differs from the definition of GDP (i.e., value added). Therefore, second, to make equation (3.114) ready for estimation, it will be reformulated by substituting aggregate output in log-deviations (y_t) with real GDP in log-deviations, which will be denoted by $\tilde{y}_t$ henceforth. To do so, let us formulate the relation between real GDP and aggregate output in the presence of intermediate goods as:

$$\tilde{Y}_t = Y_t - \frac{P_{F,t}}{P_{H,t}} M_{F,t} - M_{H,t} \tag{3.115}$$

where real GDP equals aggregate output minus real total expenditure made on intermediate goods. Log-linearization of equation (3.115) gives:

$$y_t = \frac{\bar{\tilde{Y}}\,\bar{P}_H}{\bar{\tilde{Y}}\,\bar{P}_H + \bar{P}_H \bar{M}_H + \bar{P}_F \bar{M}_F} \tilde{y}_t + \frac{\bar{P}_F \bar{M}_F}{\bar{\tilde{Y}}\,\bar{P}_H + \bar{P}_H \bar{M}_H + \bar{P}_F \bar{M}_F} (p_{F,t} + m_{F,t} - p_{H,t})$$

$$+ \frac{\bar{P}_H \bar{M}_H}{\bar{\tilde{Y}}\,\bar{P}_H + \bar{P}_H \bar{M}_H + \bar{P}_F \bar{M}_F} m_{H,t} \tag{3.116}$$

We use log-linearized versions of equations (3.57) and (3.58) to eliminate $m_{H,t}$ and $m_{F,t}$ in equation (3.116) and then solve for y_t in the following form

$$y_t = \frac{1}{1+\ (1-\phi)(\overline{s}_{M_F} + \overline{s}_{M_H})}\tilde{y}_t + \frac{\overline{s}_{M_F}}{1+\ (1-\phi)(\overline{s}_{M_F} + \overline{s}_{M_H})}\left[\left(\frac{\rho \overline{s}_{M_H}}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}} - 1\right) p_{H,t}\right.$$

$$\left. + \left(1 - \frac{\rho(\overline{s}_N + \overline{s}_{M_H})}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}}\right) p_{F,t} + \left(\frac{\rho \overline{s}_N}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}} w_t\right)\right]$$

$$+ \frac{\overline{s}_{M_H}}{1+\ (1-\phi)(\overline{s}_{M_F} + \overline{s}_{M_H})}\left[\left(\frac{\rho \overline{s}_{M_F}}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}}\right) p_{F,t} - \left(\frac{\rho(\overline{s}_N + \overline{s}_{M_F})}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}}\right) p_{H,t}\right.$$

$$\left. + \left(\frac{\rho \overline{s}_N}{\overline{s}_N + \overline{s}_{M_H} + \overline{s}_{M_F}} w_t\right)\right]$$

(3.117)

Equation (3.117) is obtained utilizing equations (3.64) - (3.66) and the following ones:

$$\frac{\alpha_H \left(\frac{\overline{P}_H \alpha_F}{\overline{P}_F \alpha_H}\right)^{1-\rho}}{\alpha_F + \alpha_H \left(\frac{\overline{P}_H \alpha_F}{\overline{P}_F \alpha_H}\right)^{1-\rho} + \alpha_N \left(\frac{\overline{W} \alpha_F}{\overline{P}_F \alpha_N}\right)^{1-\rho}} = \frac{\frac{\overline{P}_H}{\overline{P}}\left(\frac{\alpha_H \overline{W}}{\alpha_N \overline{P}_H}\right)^{\rho}}{\frac{\overline{W}}{\overline{P}} + \frac{\overline{P}_H}{\overline{P}}\left(\frac{\alpha_H \overline{W}}{\alpha_N \overline{P}_H}\right)^{\rho} + \frac{\overline{P}_F}{\overline{P}}\left(\frac{\alpha_F \overline{W}}{\alpha_N \overline{P}_F}\right)^{\rho}} \quad (3.118)$$

$$\frac{\alpha_F \left(\frac{\overline{P}_F \alpha_H}{\overline{P}_H \alpha_F}\right)^{1-\rho}}{\alpha_H + \alpha_F \left(\frac{\overline{P}_F \alpha_H}{\overline{P}_H \alpha_F}\right)^{1-\rho} + \alpha_N \left(\frac{\overline{W} \alpha_H}{\overline{P}_H \alpha_N}\right)^{1-\rho}} = \frac{\frac{\overline{P}_F}{\overline{P}}\left(\frac{\alpha_F \overline{W}}{\alpha_N \overline{P}_F}\right)^{\rho}}{\frac{\overline{W}}{\overline{P}} + \frac{\overline{P}_H}{\overline{P}}\left(\frac{\alpha_H \overline{W}}{\alpha_N \overline{P}_H}\right)^{\rho} + \frac{\overline{P}_F}{\overline{P}}\left(\frac{\alpha_F \overline{W}}{\alpha_N \overline{P}_F}\right)^{\rho}} \quad (3.119)$$

$$\frac{\alpha_N\left(\frac{\bar{W}\alpha_F}{\bar{P}_F\alpha_N}\right)^{1-\rho}}{\alpha_F+\alpha_H\left(\frac{\bar{P}_H\alpha_F}{\bar{P}_F\alpha_H}\right)^{1-\rho}+\alpha_N\left(\frac{\bar{W}\alpha_F}{\bar{P}_F\alpha_N}\right)^{1-\rho}}=\frac{\alpha_N\left(\frac{\bar{W}\alpha_H}{\bar{P}_H\alpha_N}\right)^{1-\rho}}{\alpha_H+\alpha_F\left(\frac{\bar{P}_F\alpha_H}{\bar{P}_H\alpha_F}\right)^{1-\rho}+\alpha_N\left(\frac{\bar{W}\alpha_H}{\bar{P}_H\alpha_N}\right)^{1-\rho}}$$

$$=\frac{\frac{\bar{W}}{\bar{P}}}{\frac{\bar{W}}{\bar{P}}+\frac{\bar{P}_H}{\bar{P}}\left(\frac{\alpha_H\bar{W}}{\alpha_N\bar{P}_H}\right)^{\rho}+\frac{\bar{P}_F}{\bar{P}}\left(\frac{\alpha_F\bar{W}}{\alpha_N\bar{P}_F}\right)^{\rho}} \tag{3.120}$$

Finally, to obtain the NKPC equation for domestic inflation in terms of observables, substitute equation (3.117) into equation (3.114), gather terms and simplify to obtain:

$$\pi_{H,t}=\frac{\theta\beta}{\Delta}E_t\pi_{H,t+1}+\frac{\omega}{\Delta}\pi_{H,t-1}+\frac{(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\frac{(\phi-1)}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}\tilde{y}_t\right.$$
$$+\left(\frac{\rho(\phi-1)\bar{s}_{M_H}}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}\frac{\bar{s}_N}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}+\frac{\bar{s}_N}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}\right)\left(w_t-p_{H,t}\right)$$
$$+\left(\frac{(\phi-1)\bar{s}_{M_F}}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}+\frac{\bar{s}_{M_F}}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}\right)\left(p_{F,t}-p_{H,t}\right)$$
$$\left.+\left(\frac{\rho(\phi-1)\bar{s}_{M_F}}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}\frac{\bar{s}_N}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}\right)\left(w_t-p_{F,t}\right)\right] \tag{3.121}$$

Equation (3.121) shows that real marginal cost is a function of real GDP and the relative prices of the three production factors (1) domestic labor and domestic intermediate inputs (real wages), w–p_H, (2) domestic labor and imported intermediate inputs, $w–p_F$, and (3) domestic and imported intermediate inputs (the terms of trade), $p_F–p_H$. The relative prices of the three production factors and output enter marginal cost with weights that are determined by their steady-state shares and the elasticity of substitution between them. The output term included in marginal cost captures the rise in marginal costs when output is above equilibrium given decreasing marginal returns in the variable factors of production.

III.C IMPORTER FIRMS

The economy is populated by a continuum of local retailing firms that import the foreign produced differentiated good *z* at a cost ($P^*_{F,t}(z)/E_t$) where $P^*_{F,t}(z)$ is the foreign currency price of the imported good *z* and E_t is the level of the nominal exchange rate defined as the foreign currency price of a domestic currency. Thus, for the imported goods LOOP holds "at the dock".

The imported goods could be used either as final goods by domestic consumers or intermediate goods by domestic firms. The importing firms like domestic firms set the domestic currency price of the imported good by solving an optimal (dynamic) problem assuming Calvo type pricing and rule of thumb behaviour. This gives rise to a hybrid NKPC for import price inflation. Thus for the final buyers of these goods, either being consumers or firms, the LOOP does not hold in the short run while complete pass-through is reached only asymptotically, implying a long-run holding of the LOOP. There is *incomplete exchange rate pass through* for both final and intermediate goods.

Now, let us take a closer look at the theoretical formulation of the dynamics of import pricing. The importing firms, like domestic firms, are allowed to change their price with a probability of $(1\text{-}\theta)$. We also assume that within the group of Calvo price setter importer firms, only $(1\text{-}\omega)$ are able to optimally set their prices in period t, while the remaining ω set their prices according to a backward looking rule of thumb updating their prices with past inflation.

The aggregate import price level evolves according to the following rule in log-deviations likewise the domestic price level (3.89):

$$p_{F,t} = \theta p_{F,t-1} + (1-\theta) p_{F,t}^{N} \tag{3.122}$$

where the index of *newly* set import prices that are allowed to adjust in period t are denoted by $p_{F,t}^{N}$. Let $p_{F,t}^{f}$ denote the log-linearized *optimal* price set by a *forward* looking importer firm at t and $p_{F,t}^{b}$ denote the log-linearized price set by a *backward* looking importer firm. Then the log-linearized index for the newly set import prices in period t, $p_{F,t}^{N}$, can be expressed in the same way analogous to (3.90) as:

$$p_{F,t}^{N} = (1-\omega) p_{F,t}^{f} + \omega p_{F,t}^{b} \tag{3.123}$$

where the backward looking import price in log-deviations is again assumed to be given by:

$$p_{F,t}^{b} = p_{F,t-1}^{N} + \pi_{F,t-1} \tag{3.124}$$

and $\pi_{F,t} = p_{F,t} - p_{F,t-1}$.

The forward looking importing firm chooses a price $P_{F,t}^{f}(z)$, expressed in units of domestic currency, for the z^{th} good that she imports that maximize:

$$E_t \sum_{s=0}^{\infty} \beta^s \theta^s \left(P_{F,t}^{f}(z) - \left(P_{F,t+s}^{*}(z) \big/ E_{t+s} \right) \right) \left(C_{F,t+s}(z) + M_{F,t+s}(z) \right) \tag{3.125}$$

subject to

$$C_{F,t+s}(z) = \left(\frac{P^f_{F,t}(z)}{P_{F,t+s}} \right)^{-k} C_{F,t+s} \tag{3.126}$$

$$M_{F,t+s}(z) = \left(\frac{P^f_{F,t}(z)}{P_{F,t+s}} \right)^{-k} M_{F,t+s} \tag{3.127}$$

where the last two equations follow from the demand constraints (3.19) and (3.75), θ^s is the probability that the forward looking price $P^f_{F,t}(z)$ set for the imported good *z* at time *t* still holds *s* periods ahead, $C_{F,t+s}(z)$ denotes the imported good *z* consumed as final good in period *t+s* and $M_{F,t+s}(z)$ denotes the imported intermediate good z used in period *t+s* for domestic production.

In the above maximization problem, denote the sum $\left(C_{F,t+s}(z) + M_{F,t+s}(z)\right)$ with $IM_{t+s}(z)$, which gives the total imports of good *z*[70]. Then, $IM_{t+s}(z)$, using equations (3.126) and (3.127) can be rewritten in the following form:

$$C_{F,t+s}(z) + M_{F,t+s}(z) = \left(\frac{P^f_{F,t}(z)}{P_{F,t+s}} \right)^{-\kappa} \left(C_{F,t+s} + M_{F,t+s} \right)$$

$$IM_{t+s}(z) = \left(\frac{P^f_{F,t}(z)}{P_{F,t+s}} \right)^{-\kappa} \left(C_{F,t+s} + M_{F,t+s} \right)$$

$$IM_{t+s}(z) = \left(\frac{P^f_{F,t}(z)}{P_{F,t+s}} \right)^{-\kappa} IM_{t+s} \tag{3.128}$$

[70] Follows from the equilibrium condition in the import market of good *z*. The total imports of good *z* (import supply) amounts to the total import demand which is comprised of final and intermediate import demands.

where this time the sum $\left(C_{F,t+s}+M_{F,t+s}\right)$ is denoted by IM_{t+s}, which gives the total imports of the home country[71]. Thus the total cost of importing good z to the local retailer at time $t+s$ can be rewritten as $\left(P^{*}_{F,t+s}(z)\big/E_{t+s}\right)IM_{t+s}(z)$ and total revenue that he earns as $P^{f}_{F,t}(z)IM_{t+s}(z)$.

Utilizing equation (128), the optimal problem of importer z reduces to maximize:

$$E_t\sum_{s=0}^{\infty}\beta^{s}\theta^{s}\left(P^{f}_{F,t}(z)-\left(P^{*}_{F,t+s}(z)\big/E_{t+s}\right)\right)IM_{t+s} \tag{3.129}$$

subject to

$$IM_{t+s}(z)=\left(\frac{P^{f}_{F,t}(z)}{P_{F,t+s}}\right)^{-\kappa}IM_{t+s} \tag{3.130}$$

As each retailer firm that chooses a new price for the good that he imports in period t faces exactly the same decision problem, the optimal price $P^{f}_{F,t}(z)$ is the same for all of them and so in equilibrium all prices that are chosen in period t have the common value, $P^{f}_{F,t}$ (i.e., $P^{f}_{F,t}(z)=P^{f}_{F,t}$ for all $z\in(0,1)$ and t). Thus, the first order condition of the importer firm's problem becomes[72]:

$$E_t\sum_{s=0}^{\infty}\beta^{s}\theta^{s}\left\{(1-\kappa)\left(P^{f}_{F,t}\right)^{-\kappa}\left(P_{F,t+s}\right)^{\kappa}IM_{t+s}\right.$$

[71] This equality follows from the equilibrium condition in the imports market of the home country. This equilibrium condition can be obtained in a way analogous to the goods market equilibrium condition derived in subsection III.B.2, by specifying an index for aggregate imports of the home country in a similar way done for aggregate output (3.52).

[72] The aggregate foreign price index denominated in foreign currency, equation (3.34), is used to rewrite the first order condition entirely in aggregate terms.

$$+\kappa\left(P_{F,t}^{f}\right)^{-\kappa-1}\left(P_{F,t+s}^{*}\big/E_{t+s}\right)P_{F,t+s}^{\kappa}IM_{t+s}\Big\}=0 \tag{3.131}$$

or

$$P_{F,t}^{f}=\frac{\kappa}{\kappa-1}\frac{E_t\sum_{s=0}^{\infty}\left(\theta\beta\right)^{s}\left(P_{F,t+s}^{*}\big/E_{t+s}\right)P_{F,t+s}^{\kappa}IM_{t+s}}{E_t\sum_{s=0}^{\infty}\left(\theta\beta\right)^{s}P_{F,t+s}^{\kappa}IM_{t+s}} \tag{3.132}$$

Log-linearization of equation (3.132) yields:

$$p_{F,t}^{f}=\left(1-\theta\beta\right)E_t\sum_{s=0}^{\infty}\left(\theta\beta\right)^{s}\left(\psi_{F,t+s}+p_{F,t+s}\right) \tag{3.133}$$

The price setting problem facing firms in the rest of the world is also identical to that of domestic firms, and leads to an optimal price setting rule analogous to (3.21).

Equation (3.133) shows the rule (in log-deviations) according to which that the importing optimizing firm will set its price.

Rewrite equation (3.133) in the following form:

$$p_{F,t}^{f}=\left(1-\theta\beta\right)\left(\psi_{F,t}+p_{F,t}\right)+\left(1-\theta\beta\right)E_t\sum_{s=1}^{\infty}\left(\theta\beta\right)^{s}\left(\psi_{F,t+s}+p_{F,t+s}\right) \tag{3.134}$$

Note that if θ equals zero, equation (3.134) reduces to a LOOP equation where,

$$p_{F,t}^{f}=\psi_{F,t}+p_{F,t}$$

$$p_{F,t}^{f}=(p_t^{*}-e_t)-p_{F,t}+p_{F,t}$$

$$p_{F,t}^{f} = (p_{F,t}^{*} - e_t) \tag{3.135}$$

Thus, parameter θ also governs the *degree of pass through*.

Combining equations (3.122) - (3.124) and (3.133) in the same way explained in subsection III.B.3.1 (following the steps shown with equations (3.100) – (3.111)) a hybrid NKPC equation characterizing the imported goods inflation, similar to equation (3.113), can be obtained as:

$$\pi_{F,t} = \frac{\beta\theta}{\Delta} E_t \pi_{F,t+1} + \frac{\omega}{\Delta} \pi_{F,t-1} + \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta} \psi_{F,t} \tag{3.136}$$

where $\Delta = \theta + \omega(1-\theta(1-\beta))$ and expectations are conditional upon the information set available at time *t*, i.e. $E_t\left\{\pi_{F,t+1}\right\} = E\left\{\pi_{F,t+1} \middle| \Omega_t\right\}$.

In terms of equation (3.136), when the import price index of the foreign good exceeds the domestic price index of the imported good, owing to a nominal depreciation of the home currency or an increase in the foreign currency price of the foreign good, the costs of the importing firms increase and this is reflected as an increase in import price inflation. Therefore, an increase in the LOOP gap works like an increase in the real marginal costs of the importing firms and replaces the real marginal cost term in equation (3.113).

Equation (3.136) can be written in an estimable form by substituting equation (3.51) for the *LOOP gap term*, $\psi_{F,t}$:

$$\pi_{F,t} = \frac{\beta\theta}{\Delta} E_t \pi_{F,t+1} + \frac{\omega}{\Delta} \pi_{F,t-1} + \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta} \left(-q_t - (1-\gamma)s_t\right) \tag{3.137}$$

III.D CPI BASED NKPC

So far we have derived two different NKPC equations for the domestic economy. One gives the dynamics of domestic inflation and is represented by equation (3.121), and the other describes the import price inflation and is given by equation (3.137). However, there is one more important NKPC specification for the open economy, and this is the one that describes the CPI inflation. With the help of equations (3.36), (3.121) and (3.137), a NKPC for CPI inflation can be derived.

Substitute equations (3.121) and (3.137) into equation (3.36) to obtain the following equation:

$$\pi_t = (1-\gamma)\frac{\theta\beta}{\Delta}E_t\pi_{H,t+1} + \gamma\frac{\theta\beta}{\Delta}E_t\pi_{F,t+1} + (1-\gamma)\frac{\omega}{\Delta}\pi_{H,t-1} + \gamma\frac{\omega}{\Delta}\pi_{F,t-1}$$

$$+\frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\frac{(\phi-1)}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}y_t\right.$$

$$+\left(\frac{\rho(\phi-1)\overline{s}_{M_H}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}+\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t - p_{H,t}\right)$$

$$+\left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}+\frac{\overline{s}_{M_F}}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(p_{F,t} - p_{H,t}\right)$$

$$\left.+\left(\frac{\rho(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t - p_{F,t}\right)\right]$$

$$+\frac{\gamma(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}\left[-q_t-(1-\gamma)s_t\right] \qquad (3.138)$$

In the above expression, taking equation (3.36) one period forward the first and second term equals $(\theta\beta/\Delta)E_t\{\pi_{t+1}\}$ and then lagging equation (3.36) one period the third and fourth term equals $(\omega/\Delta)\pi_{t-1}$. Thus, the NKPC equation for CPI inflation can be obtained as:

$$\pi_t = \frac{\theta\beta}{\Delta}E_t\pi_{t+1} + \frac{\omega}{\Delta}\pi_{t-1} + \frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\frac{(\phi-1)}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}y_t\right.$$

$$+\left(\frac{\rho(\phi-1)\overline{s}_{M_H}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}+\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t-p_{H,t}\right)$$

$$+\left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}+\frac{\overline{s}_{M_F}}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(p_{F,t}-p_{H,t}\right)$$

$$\left.+\left(\frac{\rho(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t-p_{F,t}\right)\right]$$

$$+\frac{\gamma(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}\left[-q_t-(1-\gamma)s_t\right] \quad (3.139)$$

Denote $\frac{\theta\beta}{\Delta}$, $\frac{\omega}{\Delta}$, $\frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}$ and $\frac{\gamma(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}$ by $\gamma_f, \gamma_b, \lambda_{mc}$ and $\lambda_{loopgap}$, respectively and rewrite equation (3.139) in the *reduced form* parameters $\gamma_f, \gamma_b, \lambda_{mc}$ and $\lambda_{loopgap}$:

$$\pi_t = \gamma_f E_t \pi_{t+1} + \gamma_b \pi_{t-1} + \lambda_{mc} \left[\frac{(\phi-1)}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})} y_t \right.$$

$$+ \left(\frac{\rho(\phi-1)\overline{s}_{M_H}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})} \frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}} + \frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}} \right) \left(w_t - p_{H,t} \right)$$

$$+ \left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})} + \frac{\overline{s}_{M_F}}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}} \right) \left(p_{F,t} - p_{H,t} \right)$$

$$\left. + \left(\frac{\rho(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})} \frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}} \right) \left(w_t - p_{F,t} \right) \right]$$

$$+\lambda_{loopgap} \left[-q_t - (1-\gamma) s_t \right] \tag{3.140}$$

From equation (3.140) it is clear that the CPI inflation is influenced not only by the *real marginal cost term* (the term in square brackets), but also the *LOOP gap term* $\psi_{F,t}$ ($\psi_{F,t} = -q_t - (1-\gamma)s_t$). The novelty of this equation lies not only in the presence of this LOOP gap term in the NKPC equation but also the formulation of the real marginal cost term in the square brackets.

The hybrid NKPC given in equation (3.140) will display *inflation inertia* if and only if the backward looking component γ_b>0. The key condition that will ensure this is ω>0. If γ_b>0 but the forward looking component is found to be greater than the backward looking component (i.e. $\gamma_f > \gamma_b$), then the inflation is said to be less inertial with expectations of future demand and cost conditions playing a greater role in its evolution. This discussion makes it clear why the parameter ω was defined as the degree of inflation inertia in subsection III.B.3.

In Monacelli (2005) equations (3.113) and (3.136) are not derived in hybrid form and the production technology is assumed to be simply linear in labor causing constant marginal costs. However, we have generalized the production technology by including domestically produced and imported goods to substitute imperfectly with labor and also assumed fixed capital. In Rumler (2007), on the other hand, LOOP is assumed to hold for all goods and the NKPC equation is derived only for domestic goods, whereas in deriving (3.139) we assumed that LOOP does not hold for imported goods and derive the NKPC equation for consumer goods.

It should be noted that the specification we obtained in equation (3.139) nests the other closed and open economy model NKPC specifications. If we remove all the open economy elements from the model and assume that only labor is used in the production process, the NKPC equation obtained for domestic inflation in equation (3.121) reduces to the closed economy specifications of Galí et al. (2001)[73]. If further the weight of fixed capital in production $(1-(1/\phi))$ is set to zero, equation (3.121) reduces to the closed economy specifications of Galí and Gertler (1999) with constant marginal cost. If we retain the open economy elements but assume that LOOP holds for all goods, then, equation (3.135) would govern the evolution of the domestic currency price of imports and equation (3.39) would be used to derive the CPI based NKPC equation. Such a specification is derived by Mihailov, Rumler and Scharler (2008)

[73] This can be done by setting the share of imported final goods in the domestic consumption basket (γ) to zero, assuming that no imported intermediate goods are used in the production process (the share of imported intermediate goods in GDP, $\overline{s}_{M_F}$, and their weight in the production function, α_F, are set to zero) and further assuming that no domestic intermediate goods are used in the production process (the share of domestically produced intermediate goods in GDP, $\overline{s}_{M_H}$, and their weight in the production function, α_H, are set to zero)

CHAPTER IV

ESTIMATION RESULTS

This chapter presents estimates of the NKPC equation derived in Chapter III. Our findings indicate that, conditional on the path of real marginal costs and the LOOP gap, the open economy hybrid NKPC specification may track the actual path of inflation in Turkey reasonably well, including the 1994 and 2000-01 crisis.

The chapter proceeds as follows. Section IV.A presents the data used in the study and its sources along with a discussion of the filtering techniques used to make the data correspond to the derived NKPC model. Section IV.B demonstrates the estimates of the NKPC together with the results of the various robustness tests conducted. For this purpose, first, subsection IV.B.1 presents the empirical specification of the NKPC model used in estimation along with some issues regarding the empirical implementation of the model. Second, subsection IV.B.2 describes the econometric methodology used in the study which is based on the two step generalized method of moments (GMM) estimator. It also presents the hypothesis tests used throughout the study that have been proposed within the GMM framework. Then, the estimation results of the model's structural and reduced from parameters are presented and discussed in subsection IV.B.3. Starting with subsection IV.B.4 we report the results of the tests performed to verify the empirical validity of the estimated NKPC. First, subsection IV.B.4 contains an assessment of the goodness of fit of NKPC equation estimated for Turkey by introducing a concept called *fundamental inflation*. Then, subsection IV.B.5 compares the estimates of our model's parameters with those obtained from a *closed economy model* and an alternative *open economy model*. We start by reporting the estimation results of these models' structural parameters in subsection IV.B.5.1. Then, for evaluation, subsection IV.B.5.2 uses measures of fit to compare the fundamental rate of inflation obtained from each specification with the actual development of inflation. Subsection IV.B.5.3 ends by analyzing whether there are significant differences among parameter estimates of the alternative models and interpreting the results. Subsection IV.B.6 continues to present the results of the robustness tests conducted by describing the econometric issues associated with the standard two step GMM, *continuous updating GMM (CU-GMM) and iterated GMM estimations*, and then reporting the estimation results of the NKPC model based on the CU-GMM and iterated GMM estimators. The robustness of our results to the estimation of the *closed form solution* is analyzed in subsection IV.B.7. Finally, subsection IV.B.8 concludes by investigating the *stability* of the NKPC over the post 1989 period. This subsection starts by giving an overview of the Turkish economy in the post 1989 period. Then, subsection IV.B.8.2 introduces the econometric structural break tests methodology used in the study and subsection IV.B.8.3 reports the results of these tests. IV.B.8.4 ends by discussing, whether over the recent past, the dynamics of inflation have changed with the adoption of the inflation targeting framework.

IV.A DATA

The study uses *quarterly* data to estimate the open economy hybrid NKPC model developed in Chapter III over the period 1988:1 - 2009:4. The raw form of the data is obtained from the official web site of TurkStat (2009a, 2009b, 2009c and 2009d).

We have used the logarithm of the import unit value index (2003 based) calculated in terms of Turkish liras (TRY) for the *price of imported goods denoted in domestic currency*, P_F. The *domestic output prices*, P_H, are proxied by the logarithm of the GDP deflator (1998 based). This series is calculated by taking the deflator calculated from the 1998 based real GDP series (nominal GDP/real GDP) backwards using the change rates of the deflator series calculated from the 1987 based real GDP series. For the *real exchange rate*, *Q*, the logarithm of the consumer price index (CPI) based real effective exchange rate (REER) index (1995 based) is used. The *nominal wage*, *W*, is proxied by the nominal wage index (2005 based) in the manufacturing industry. The 2005 based nominal wage data for the whole sample period is obtained by taking the 2005 based series backwards using the growth rates of the 1997 based index of wages per production hour worked in the manufacturing industry. The data on the consumer price index (CPI), *P*, for the periods 1983 – 1989, 1990 – 1995, 1996 – 2004, 2005-2009 were 1978-79, 1987, 1994 and 2003 based, respectively. The indices were combined using the monthly change rates. *Real GDP*, $\tilde{Y}$, is expressed in thousands of 1998 Turkish liras (TRYs) and obtained by taking backwards the 1998 based series using the 1987 based real GDP series change rates. For *terms of trade*, *S*, the logarithm of the terms of trade (2003 based) series calculated in terms of TL is used.

Inflation rates (i.e., CPI inflation, π, domestic inflation, π_H, and import price inflation, π_F) are calculated as the quarter on quarter logarithmic changes in the respective price indices (P, P_H and P_F). To make all the index series comparable with each other we have converted the base year of the entire index series to the most recent base year used in calculations by TURKSTAT, which was 2003.

Prior to estimation, the CPI, GDP deflator and the real GDP series were seasonally adjusted following the methodology used by the Central Bank of the Republic of Turkey (*CBRT*). Seasonal adjustments and the removal of calendar effects were made using the *Demetra*[74] software of the *Eurostat* and the *Tramo-Seats* method.

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[74] DEMETRA includes the most important features of Tramo/Seats (April 2005) and X-12-Arima (0.3 release): pre-adjustment with automatic detection and correction of outliers, removing of *calendar effects*, automatic model identification/selection, forecast, seasonal adjustment and trend estimation, revision history and sliding span analysis, and diagnostic checking. The version used is Demetra 2.1, release 09.07.07 . Available online: http://circa.europa.eu/irc/dsis/eurosam/info/data/demetra.htm.

The solution of our open economy hybrid NKPC model requires characterizing the behavior of the variables in the form of *temporary departures from their steady state values* (i.e. variables are log-linearized around their respective steady state values). Thus, the corresponding data should be represented in an analogous fashion. In much of the literature, trends are removed prior to estimation so that the departures from the steady state refer to the transitory or cyclical component of each variable. The *detrending* techniques commonly used in the literature involve the HP filter, subtracting a constant mean or fitting linear, quadratic and cubic trends[75].

However, these approaches are administered under the *implicit* assumption that the data follow roughly constant growth rates (Dejong and Dave, 2007, pp. 33-38). Thus, choosing either one of them is problematic in our empirical context since neither of our data seem to have constant average growth rates throughout the sample period. Therefore, we have used the *band pass filter* to isolate the cyclical component of our data. Since it is not possible to apply the ideal band pass filter because it requires infinite unfiltered data, *approximate band pass filters* were estimated. Within this context, the two most popular approaches include *fixed length symmetric filter* due to Baxter and King (1999) and *full sample asymmetric filter* due to Christiano and Fitzgerald (2003) (CF). The *fixed length filters* require that we use the same number of lead and lag terms for every weighted moving average. Thus, a filtered series computed using q leads and lags observations will lose q observations from both the beginning and end of the original sample. In contrast, the *asymmetric filtered* series do not have this requirement and can be computed to the ends of the original sample[76]. Therefore, to not reduce the length of our sample, we have used the CF version of the band pass filter to isolate the cyclical component of the variables involved prior to estimation.

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[75] See Galí and Gertler (1999), Galí et al. (2001), Rumler (2007) and Leith and Malley (2007).

[76] For technical details see Baxter and King (1999) and Christiano and Fitzgerald (2003).

IV.B RESULTS

IV.B.1 Empirical Specification

In Chapter III equation (3.139), we derived the following CPI based NKPC equation for Turkey;

$$\pi_t = \frac{\theta\beta}{\Delta}E_t\pi_{t+1} + \frac{\omega}{\Delta}\pi_{t-1} + \frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\frac{(\phi-1)}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}y_t\right.$$

$$+\left(\frac{\rho(\phi-1)\overline{s}_{M_H}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}+\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t-p_{H,t}\right)$$

$$+\left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}+\frac{\overline{s}_{M_F}}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(p_{F,t}-p_{H,t}\right)$$

$$\left.+\left(\frac{\rho(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t-p_{F,t}\right)\right]$$

$$+\frac{\gamma(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}\left[-q_t-(1-\gamma)s_t\right] \tag{4.1}$$

where $\Delta = \theta + \omega(1-\theta(1-\beta))$ and the expectation of π_{t+1} at $t, E_t\left\{\pi_{t+1}\right\}$, is the mathematical expectation conditional on all the information available at t implied by the model, i.e., Ω_t. This is formally stated as $E_t\left[\pi_{t+1}\right] = E\left[\pi_{t+1}\middle|\Omega_t\right]$.

To obtain the final *structural form* of this equation to be used in estimation, replace the expectations term, $E_t\left\{\pi_{t+1}\right\}$, in the above equation by $\left(\pi_{t+1}-\upsilon_{t+1}\right)$ from $\pi_{t+1} = E_t\left\{\pi_{t+1}\right\} + \upsilon_{t+1}$ where υ_{t+1} is the (rational) expectational error made in period *t*. Thus, the final structural form to be estimated can be rewritten in the following form

$$\pi_t = \frac{\theta\beta}{\Delta}\pi_{t+1} + \frac{\omega}{\Delta}\pi_{t-1} + \frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\frac{(\phi-1)}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}y_t\right.$$

$$+\left(\frac{\bar{s}_N}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}\right)\left(w_t - p_{H,t}\right)$$

$$\left.+\left(\frac{(\phi-1)\bar{s}_{M_F}}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}+\frac{\bar{s}_{M_F}}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}\right)\left(p_{F,t}-p_{H,t}\right)\right]$$

$$+\frac{\rho(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\left(\frac{(\phi-1)\bar{s}_{M_F}}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}\frac{\bar{s}_N}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}\right)\left(w_t-p_{F,t}\right)\right.$$

$$\left.+\frac{(\phi-1)\bar{s}_{M_H}}{1+(1-\phi)(\bar{s}_{M_F}+\bar{s}_{M_H})}\frac{\bar{s}_N}{\bar{s}_N+\bar{s}_{M_F}+\bar{s}_{M_H}}\left(w_t-p_{H,t}\right)\right]$$

$$+\frac{\gamma(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}(-q_t)$$

$$+\frac{\gamma(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}(-s_t)+u_t \qquad (4.2a)$$

where $u_t = \varepsilon_t - \left(\theta\beta/\Delta\right)\upsilon_{t+1}$ and ε_t is a disturbance term that is uncorrelated with past information. As discussed previously in Chapter II, ε_t is specified to capture (unexplained) transitory deviations from the theory, structural misspecifications of the model or approximation errors induced by the linearization, measurement error and errors due to non-linearities in the theory and data mismeasurement.

For ease of notation rewrite (4.2a) as follows:

$$\pi_t = \frac{\theta\beta}{\Delta}\pi_{t+1} + \frac{\omega}{\Delta}\pi_{t-1} + \frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}F_t$$

$$+\frac{\rho(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}Z_t + \frac{\gamma(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}K_t$$

$$+\frac{\gamma(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}L_t + u_t \qquad (4.2b)$$

where we have denoted the first term in square brackets, second term in square brackets, $-q_t$ and $-s_t$ in equation (4.2a) by $F_{t,}$, Z_t, K_t and L_t, respectively.

Using equation (4.2b) our strategy is to estimate the structural form parameters θ (Calvo fraction of firms that keep their prices fixed), β (discount factor of firms), ω (share of firms that follow a backward looking rule of thumb), ρ (constant elasticity of substitution between labor, imported and domestically produced intermediate inputs) and γ (degree of openness) *conditional* on plausible values for κ (elasticity of demand of the firm's product) and ϕ (elasticity of substitution between variable capital and variable factors of production). We obtain measures for ϕ and κ based on information about the steady state values of μ (mark-up of prices over marginal cost) and shares of labor, domestic intermediate and imported intermediate inputs in total domestic production.

Given our assumptions, steady state mark-up, μ, should equal to the desired mark-up (mark-up under perfectly flexible prices) which is determined by the usual Lerner formula, $\mu = \kappa /(\kappa -1)$. Thus we obtain κ using an estimate of steady state (sample mean) value of μ. Following Yeldan (2006), who reports the average mark-up rates in the private manufacturing industry for Turkey over 1981-1999, we adopt a baseline value for μ equal to 1.373 which corresponds to a mark-up rate of 40 percent[77]. This gives a value for κ equal to 3.678.

We have derived an estimate for ϕ using the relationship $\phi = (1 + \bar{s}_{M_F} + \bar{s}_{M_H}) / \mu(\bar{s}_N + \bar{s}_{M_F} + \bar{s}_{M_H})$, where the steady state (sample mean) shares of labor ($\bar{s}_N$), domestic intermediate ($\bar{s}_{M_H}$) and imported intermediate inputs ($\bar{s}_{M_F}$) in total domestic production are obtained from the input-output tables when available.

We adopt a value of 0.134 for the imported intermediate input share ($\bar{s}_{M_F}$). This number is calculated by dividing the *total imported intermediate input consumption* by *gross value added* obtained from the input-output tables and then averaging across the years 1990, 1996, 1998 and 2002 for which the input-output tables were available. Likewise, domestic intermediate input share ($\bar{s}_{M_H}$) is set equal to 0.698 by averaging the share of *total domestic intermediate input consumption* in *gross value added* across the years for which input-output tables were available. Labor share ($\bar{s}_N$) is calculated again from the input-output tables by dividing the total *compensation to employees* by *gross value added*. Taking the average of this data for the available years we adopt a value of 0.261 for the steady state labor share. These numbers give a value of 1.221 for ϕ employing the relationship $\phi = (1 + \bar{s}_{M_F} + \bar{s}_{M_H}) / \mu(\bar{s}_N + \bar{s}_{M_F} + \bar{s}_{M_H})$.

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[77] Ceritoglu (2002) has also estimated mark-up rates for the manufacturing industry. However, this is done only for the period 1991-1997 and the average mark-up rate calculated from this study (which equals 1.39) is consistent with the evidence reported in Yeldan (2006) for the same time interval (1.42).

IV.B.2 Econometric Methodology

In the first subsection we describe the estimation technique used in the study that is based on the *two step generalized method of moments* (GMM) estimator proposed in Hansen (1982) and discuss some econometric issues associated with it. In the second subsection we present the overidentifying restrictions test that is used to assess model misspecification and the methods developed for testing hypothesis about the parameter vector within the GMM framework.

IV.B.2.1 The GMM Estimation

The NKPC represented by equations (4.2a) or (4.2b) is estimated using the *two step generalized method of moments* (GMM) estimator which is widely used in the literature to estimate forward looking rational expectations models.

The two step estimator is proposed in Hansen (1982) and is based on the following GMM objective function

$$Q_{two-step,T}(\theta) = g_T(\theta)'\hat{S}_T(1)^{-1} g_T(\theta) \tag{4.3}$$

where $g_T(\theta)$ gives the sample moment condition, $\hat{S}_T(1)$ is a consistent estimator of S (the variance-covariance matrix of moment conditions) obtained at the first step based on a preliminary estimator $\hat{\theta}_T(1)$. The resultant estimator is asymptotically efficient.

In our context, this estimation technique is used because not only the π_{t+1} term appearing in equations (4.2a) or (4.2b) is correlated with the error term u_t but also u_t which is a combination of two error terms may necessarily be autocorrelated and heteroscedastic[78]. But, how should the instruments be

[78] Kleibergen and Mavroeidis (2009) states that since the error term u_t is not adapted to the information at time t, it may exhibit first order autocorrelation without contradicting the model.

selected? In theory, without the ε_t term, anything dated *t* or earlier can be used as a valid instrument for the future value of π_t since the crucial requirement is that the instruments are uncorrelated with the expectational error υ_{t+1}. If expectations are rational, then the expectational error should indeed be uncorrelated with all variables dated time *t* or earlier. This follows because we are assuming that agents are making efficient use of all information available at time *t* and thus the error must stem from something that could not have been forecasted at time *t*. However, since we have used the inexact form of the NKPC equation in our study so that our error term consists of not only υ_{t+1} but also ε_t and since ε_t is conditional on Ω_{t-1}, not Ω_t; variables dated *t-1* and earlier had to be used as instruments.

As shown in Hall (2005, p. 99), the usual two step GMM estimator is invariant to curvature altering transformations of the population moment condition only in the limit when the parameter vector is overidentified. Therefore, the two step GMM estimator is sensitive to the way the orthogonality conditions are specified in case of nonlinear estimation. To circumvent this problem, it is common in the literature to estimate the NKPC in different normalizations of the moment condition. Following Galí and Gertler (1999), the following two normalizations are used in the estimation

$$E\left\{\left(\pi_t - \frac{\theta\beta}{\Delta}\pi_{t+1} - \frac{\omega}{\Delta}\pi_{t-1} - \frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\frac{(\phi-1)}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}y_t\right.\right.\right.$$

$$+\left(\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t - p_{H,t}\right)$$

$$\left.+\left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}+\frac{\overline{s}_{M_F}}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(p_{F,t}-p_{H,t}\right)\right]$$

$$-\frac{\rho(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)\Delta}\left[\left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t-p_{F,t}\right)\right.$$

$$\left.+\frac{(\phi-1)\overline{s}_{M_H}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\left(w_t-p_{H,t}\right)\right]$$

$$\left.\left.+\frac{\gamma(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}q_t+\frac{\gamma(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{\Delta}\;s_t\right)z_t\right\}=0 \qquad (4.4)$$

and

$$E\left\{\left(\Delta\pi_t-\theta\beta\pi_{t+1}-\omega\pi_{t-1}-\;\frac{(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)}\left[\frac{(\phi-1)}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}y_t\right.\right.\right.$$

$$+\left(\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t-p_{H,t}\right)$$

$$\left.+\left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}+\frac{\overline{s}_{M_F}}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(p_{F,t}-p_{H,t}\right)\right]$$

$$-\frac{\rho(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)}{(1+(\phi-1)\kappa)}\left[\left(\frac{(\phi-1)\overline{s}_{M_F}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\right)\left(w_t-p_{F,t}\right)\right.$$

$$\left.+\frac{(\phi-1)\overline{s}_{M_H}}{1+(1-\phi)(\overline{s}_{M_F}+\overline{s}_{M_H})}\frac{\overline{s}_N}{\overline{s}_N+\overline{s}_{M_F}+\overline{s}_{M_H}}\left(w_t-p_{H,t}\right)\right]$$

$$\left.\left.+\gamma(1-\omega)(1-\theta)(1-\beta\theta)q_t+\gamma(1-\gamma)(1-\omega)(1-\theta)(1-\beta\theta)\;s_t\;\right)z_t\right\}=0 \qquad (4.5)$$

In specification 1, which is given by equation (4.4), equation (4.2a) is estimated directly, whereas in the second specification (4.5), nonlinearities are minimized by multiplying all the terms with $\Delta = \theta + \omega\left[1-\theta(1-\beta)\right]$.

Furthermore, for GMM to be an appropriate estimation technique, the variables used in the estimations should be *stationary*. Therefore, as a preliminary step the variables involved in estimation (π (denoted with *INF*), X, Z, K and L) and the instrumental variables used throughout the study (see subsections IV.B.3 and IV.B.6) are pretested for the presence of *unit roots* using the Augmented Dickey Fuller (ADF) test. In choosing the lag length for the ADF test the *Akaike Information Criterion* (AIC), the *Schwarz Information Criterion* (SIC) and sequential testing of the coefficient of the last lag were used. The lag length for which at least two of the above criteria have agreed upon was chosen. If there were no agreement among the information criteria, the outcome of the criterion that provided us with the longest lag length was used, since the aim in adding the lagged difference terms in the ADF test is to remove any serial correlation present in the residuals. After choosing the lag length, the residuals were tested for serial correlation using the *Breusch-Godfrey Lagrange Multiplier* (LM) test and more lags were added if still some autocorrelation was present in the residuals. The test results are reported in Table A.1 at the Appendix section and indicate that for all series the null hypothesis of unit root is *rejected* at the 1 percent significance level.

IV.B.2.2 Hypothesis Testing

This section discusses the inference procedures developed within the GMM framework by mainly focusing on two types of tests: The overidentifying restrictions test and the methods proposed for testing hypotheses about the parameter vector[79].

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[79] Throughout this section we will follow the notation used by Hall (2005, pp. 143-170).

IV.B.2.2.i The Overidentifying Restrictions Test

Within our empirical framework, the economic model implies that υ_t, which is a $(q \times 1)$ vector of instruments, satisfies the population moment condition

$$E\left[f(\upsilon_t, \theta_0)\right] = 0 \tag{4.6}$$

where θ_0 denotes the unknown $(p \times 1)$ parameter vector.

When overidentifying restrictions are available so that $q > p$, they are used as a basis for testing the validity of the model specification via the estimated sample moment.

As discussed in Hall (2005, pp. 117-201), within the GMM framework misspecification can take two forms. First, the model can be misspecified in the sense that $E\left[f\left(\upsilon_t, \theta_0\right)\right]$ is the same for all t but there is no value of θ that makes this expectation zero. Second, the model can be structurally unstable so that $E\left[f\left(\upsilon_t, \theta_0\right)\right] = 0$ for some part of the sample but not for all of it. The overidentifying restrictions test is designed to test against the first type of these misspecifications. The second type of misspecification can be detected using specially designed structural stability tests, which is the subject of subsection IV.B.8.

Hansen (1982) has proposed testing the null hypothesis

$$H_0 : E\left[f\left(\upsilon_t, \theta_0\right)\right] = 0 \tag{4.7}$$

using the overidentifying restrictions test statistic[80]

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[80] This is also referred to as the *J-test*.

$$J_T = Tg_T\left(\hat{\theta}_T\right)' \hat{S}_T^{-1} g_T\left(\hat{\theta}_T\right) \tag{4.8}$$

where $\hat{\theta}_T$ is the second step estimator discussed in the first subsection. Hansen (1982) derived the limiting distribution of this statistic under H_0 and showed that the overidentifying test statistic given in equation (4.8) converges in distribution to a χ^2_{q-p} where *(q-p)* refers to the number of overidentifying restrictions.

IV.B.2.2.ii Testing Hypothesis about the Parameter Vector

In many cases, the restrictions implied by economic theory take the form of a set of linear or nonlinear restrictions on the parameter vector. Such restrictions can be tested using the GMM extensions of the Wald (W), Lagrange Multiplier (LM) or Likelihood Ratio (LR) tests.

Following Hall (2005, pp. 161-170) we focus on the versions of these tests proposed by Newey and West (1987). Newey and West (1987) have developed the theory for testing

$$H_0^R : r\left(\theta_0\right) = 0 \quad \text{versus} \quad H_A^R : r\left(\theta_0\right) \neq 0 \tag{4.9}$$

based on GMM estimators, where $r\left(\theta_0\right)$ is a $(s \times 1)$ vector of nonlinear functions of θ_0.

The unrestricted estimator is $\hat{\theta}_T$ and refers to the second step estimator discussed in the first subsection. The restricted estimator, denoted by $\tilde{\theta}_T$, refers to the value of θ which minimizes the GMM minimand, $Q_T\left(\theta\right)$, subject to $r\left(\theta_0\right) = 0$.

The *Wald* test examines whether the unrestricted estimator, $\hat{\theta}_T$, satisfies the restrictions with allowance for sampling error. This statistic is given by

$$W_T = Tr\left(\hat{\theta}_T\right)'\left[R\left(\hat{\theta}_T\right)\left[G_T\left(\hat{\theta}_T\right)'\hat{S}_T^{-1}G_T\left(\hat{\theta}_T\right)\right]^{-1}R\left(\hat{\theta}_T\right)'\right]^{-1}r\left(\hat{\theta}_T\right) \tag{4.10}$$

where $R(\theta) = \partial r(\theta)/\partial\theta'$ and $G_T(\theta) = T^{-1}\sum_{t=1}^{T}\left[\partial f(\upsilon_t,\theta)/\theta'\right]$ is the derivative matrix.

The *LM* test looks at whether the restricted estimator, $\tilde{\theta}_T$, satisfies the first order conditions from the unrestricted estimation and is given by

$$LM_T = Tg_T\left(\tilde{\theta}_T\right)'\hat{S}_T^{-1}G_T\left(\tilde{\theta}_T\right)\left[G_T\left(\hat{\theta}_T\right)'\hat{S}_T^{-1}G_T\left(\hat{\theta}_T\right)\right]^{-1}G_T\left(\tilde{\theta}_T\right)'\hat{S}_T^{-1}g_T\left(\tilde{\theta}_T\right) \tag{4.11}$$

The *D* or *LR-type* test examines the impact on the GMM minimand, $Q_T\left(\theta\right)$, of the imposition of the restrictions. This statistic is given by

$$LM_T = T\left[Q_T\left(\tilde{\theta}_T\right) - Q_T\left(\hat{\theta}_T\right)\right] \tag{4.12}$$

Newey and West (1987) showed that the W, LM and D test statistics given in equations (4.10) – (4.12) converge in distribution to a χ_s^2 variate where *s* refers to the number of restrictions being tested.

Hall (2005, p. 163) has discussed two main disadvantages of the Wald test applied in this context: It is not invariant to a reparametrization of the model or the restrictions and it tends to be less approximated by the χ_s^2 distribution in finite samples than the LM or D statistics. Therefore, we have refrained from using the Wald test in our empirical applications.

IV.B.3 Estimates of Structural and Reduced Form Parameters

Table 1 presents the two step GMM estimation results of the structural parameters *θ, β, ω, ρ* and *γ* and the implied estimates of the reduced form parameters $\gamma_f, \gamma_b, \lambda_{mc}$ and $\lambda_{loopgap}$ based on orthogonality conditions (4.4) and (4.5) [81]. Specifications 1 and 2 refer to equations (4.4) and (4.5), respectively. The instrument set includes a constant term and four lags of domestic price inflation, growth rate of USD-TL exchange rate, ratio of wages to import prices (i.e., $w_t - p_{F,t}$) and ratio of wages to domestic prices (i.e., $w_t - p_{H,t}$). The rows labeled *D* and *J* give the average duration of prices measured in months and the *p-value* of Hansen's test of overidentifying restrictions (the *J-test*) discussed in subsection IV.B.2.2.i and given in equation (4.8), respectively[82]. Once allowance is made for the four lagged variables needed to construct the instrument set, as well as the lead of the inflation rate, our effective sample spans the period 1989:1 – 2009:3.

In conducting the GMM estimation, we have used a *heteroscedasticity and autocorrelation consistent (HAC)* covariance matrix. The bandwidth used to compute the optimal weighting matrix is selected using the *Newey and West (1994) data based bandwidth selection method*. It is argued that the power of the overidentifying restrictions test depends crucially on this weighting matrix such that the standard J-test may lead to non rejection of the specification, although the NKPC is misspecified (Guay and Pelgrin, 2004). Thus, the use of the Newey and West (1994) method avoids us from relying on an arbitrary truncation of the HAC bandwidth as done in Galí and Gertler (1999).

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[81] The reduced form of the NKPC equation (4.2a) is given in Chapter III as equation (3.140).

[82] The average duration in months is calculated by multiplying the average duration in quarters *1/(1-θ)* by 3.

Table 1 Open economy NKPC estimates for the period 1989-2009

Estimates of Structural Parameters[a]		
	Specification 1	Specification 2
θ	0.654*** (0.060)[c]	0.632*** (0.093)
β	0.991*** (0.000)	0.992*** (0.000)
ω	0.733*** (0.005)	0.734*** (0.010)
ρ	-6.208*** (0.887)	-6.223*** (0.809)
γ	0.817*** (0.046)	0.594*** (0.068)
D	8.6	8.1
J	0.999	0.979
Estimates of Reduced Form Parameters[b]		
γ_f	0.469*** (0.023)	0.460*** (0.036)
γ_b	0.530*** (0.023)	0.539*** (0.036)
λ_{mc}	0.002** (0.001)	0.006* (0.004)
$\lambda_{loopgap}$	0.019** (0.008)	0.016* (0.009)

Notes:
[a] The first part of this table presents the two-step GMM estimates of the structural form coefficients where the nonlinear two stage least squares estimator provides the initial consistent estimator.
[b] The second part of this table presents the implied estimates of the reduced form parameters calculated from equation (3.140) and their calculated standard errors. The standard errors of the reduced form parameters are computed according to Kmenta (1986).
[c] The figures in parentheses are standard errors.
[d]Asterisks (***,**,*) denote statistical significance at 1% , 5% and 10% levels, respectively.
Source: Author's own calculations

The HAC estimator is modified a priori based on Andrews and Monahan (1992)'s *prewhitening and recolouring* technique which is proposed to make HAC estimator work better by reducing the size of the autoregressive component[83]. Andrews and Monahan (1992) and Newey and West (1994) have suggested that the use of prewhitening and recolouring improves the finite sample performance of the confidence intervals of the GMM estimators. The estimations are carried out in GRETL which minimizes the GMM criterion through numerical minimization via the *BFGS (Broyden, Fletcher, Goldfarb and Shanno)* method[84].

When Table 1 is analyzed, the first thing to note is that all the estimated reduced and structural parameters have correct signs, are in the theoretically expected range and are statistically significant in most cases at the 1 percent significance level. Second, in general, the estimates of reduced and structural form parameters are robust to different specifications of the moment conditions. Third, Hansen's J-test statistics reported in Table 1 do not reject the null hypothesis that the overidentifying moment conditions are valid and supported by the data.

In the next subsection we will present and interpret the results obtained for the structural parameters and compare them with those reported for Turkey and other countries. The same analysis will be carried within the context of the reduced form parameters in subsection IV.B.3.2.

IV.B.3.1 Structural Parameters

Estimate for the measure of price rigidity, θ, under specification 1 suggests that 65 percent of all Turkish firms leave their prices unchanged during a given quarter. This suggests an average price duration of approximately *9 months*. Under specification 2, this time an estimate of 0.63 implies that 63 percent of all Turkish firms leave their prices unchanged during a given quarter, which suggests that on average prices remain fixed for approximately *8 months*.

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[83] For technical details see Hall (2005, pp. 83-86).

[84] This is a quasi-Newton nonlinear optimization method that involves a rank three correction. For details see Greene (2003, pp. 938-939).

The above reported average price duration is *shorter* than that reported in Galí and Gertler (1999), Gagnon and Khan (2005), Kurmann (2007) and Kleibergen and Mavroeidis (2009) for the U.S and Rumler (2007), Galí et al. (2001), Gagnon and Khan (2005) and Fanelli and Polomba (in press) for the euro area. The estimates in those studies range from *10 to 20 months* for the U.S. and *14 to 33 months* for the Euro area. Only Galí et al. (2001) report an estimate of price duration for the U.S (approximately 7.5 months) that is slightly shorter than the estimate we have obtained for Turkey.

In case of the individual euro area countries, the estimated price rigidity parameters reported in Rumler (2007), Leith and Malley (2007) and Benigno and Lòpez-Salido (2006) go from 0.53 to 0.87, suggesting that the prices remain fixed on average for *6.4 to 23.2 months*. Among the Euro area countries Turkey exhibits lower price rigidity than Germany, Belgium, Italy, France, Spain and UK and slightly higher price rigidity than Greece and the Netherlands. Finland and Austria have price rigidity parameters that are very close to our estimates, which is 0.68 for Finland (corresponding to an average price duration of *9.5 months*) and 0.69 for Austria (corresponding to an average price duration of *9.7 months*). Rumler (2007) refers to these countries as having an *intermediate* degree of price rigidity and hence if Turkey were included in this Euro area sample it would have been considered among the countries having an intermediate degree of price rigidity.

Furthermore, the average price duration in Turkey is lower than the estimates reported in Leith and Malley (2007) for the two G7 countries, Canada and Japan, which equal to *12.5 and 15.4 months*, respectively. In case of South Africa, Chile and Mexico, Plessis and Burger (2006), Céspedes et al. (2005) and Ramos-Francia and Torres (2008) report average price duration estimates that range from *12 to 35 months*. Thus, Turkey is, in general, experiencing lower price rigidity than this group of countries also.

Evidently, the above result that prices, on average, are less sticky in Turkey than most of the countries previously mentioned is consistent with the fact that over the sample periods, average inflation was significantly higher in Turkey than in the aforementioned economies (Figure 4). As Taylor (2000) and Devereux and Yetman (2003) have argued, a lower and more stable inflation rate, as experienced in the case of U.S, euro area and G7 countries, could give rise to less frequent optimal price adjustments (i.e. higher average price duration).

Our findings regarding price stickiness could also be compared with those reported in other Turkish NKPC studies. The above reported average price duration is shorter than that reported in Celasun (2006) for Turkey but higher that found in Yazgan and Yılmazkuday (2005)[85]. The reported estimate of θ in these studies go from 0.33 to 0.90, and suggest that, on average, prices remain fixed for *4 to 29 months*. Evidently, in case of Yazgan and Yilmazkuday (2005), this difference is consistent with the fact that average inflation in Turkey was slightly lower in the sample period that we have considered due to the switch to an inflation targeting regime in the post-2002 period[86].

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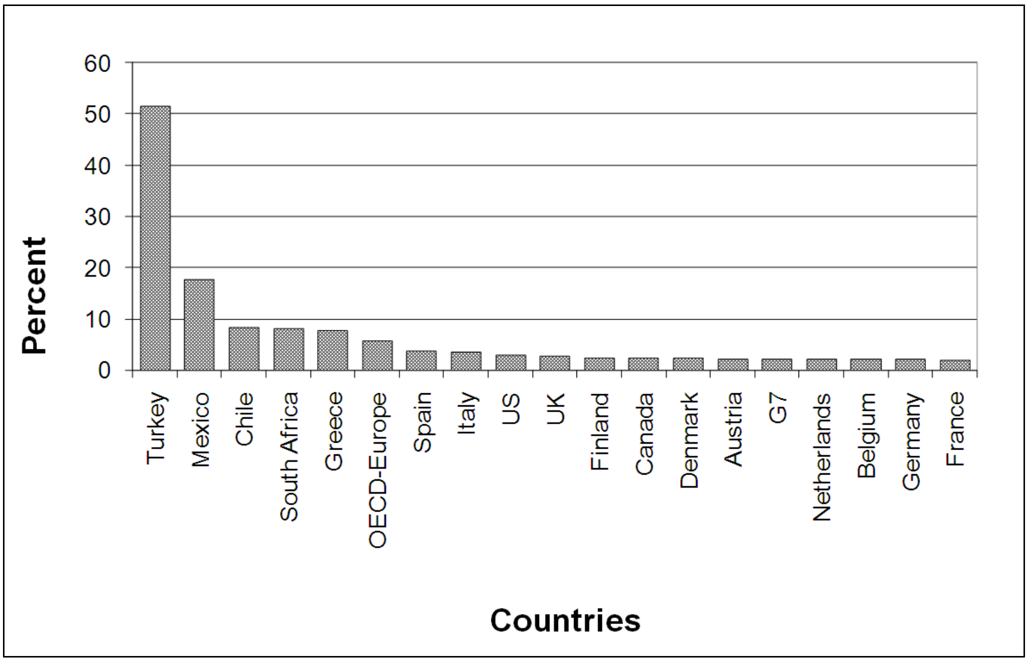
[85] Throughout this section the structural parameters are compared with those obtained in Yazgan and Yilmazkuday (2005) and Celasun (2006) because these are the only two studies that estimate the structural parameters of the NKPC for Turkey. Other studies surveyed and discussed in Chapter II estimate the NKPC only in its reduced form.

[86] See section IV.B.9 for details.



Notes: 2005 is the base year. OECD calculates five area totals or 'zones' (OECD-Total; OECD-Europe; Major seven; OECD-Total excluding high inflation countries; OECD-Europe excluding high inflation countries). Zone totals for CPI are annually chain-linked Laspeyres indices. The weights for each individual link are based on the previous year's private final consumption expenditure of Households and Non-profits institution serving Households expressed in purchasing power parity (PPP).

Figure 4 Average CPI Inflation Rate in OECD countries over the period 1988-2009

Source: OECD (2010)

On the other hand, our estimate is considerably less than that reported in Celasun (2006) and this difference can be attributed to the use of different modeling assumptions. Celasun's (2006) model overlooks an important source of openness for the Turkish economy - the presence of imported intermediate inputs. The price of imported intermediate goods is expected to change more frequently than any other input employed in the production function. We have assumed incomplete exchange rate pass through in the local currency *import* prices causing deviations from LOOP to act like marginal cost changes for the importer firm. Thus, changes in the exchange rate or foreign currency price of the foreign good that increase the costs of the importing firms are reflected as a change in the domestic currency price of the imported good. Since both variables are very volatile and import prices and domestic prices defined in terms of CPI are linked through equation (3.35), the frequent changes in imported prices are reflected as frequent changes in domestic prices. Thus, the presence of imported intermediate inputs is the main reason behind the relatively low estimate of θ in our model.

Another comparison could be made with the few studies that calculate the average price duration for Turkey using *micro price data*, notwithstanding that these are not applications of a theoretical general equilibrium NKPC model. Furthermore, these studies have very limited data coverage. They analyze micro price observations that only represent a specific group of the economy and do not encompass Turkey as a whole. Çağlayan and Filiztekin (2006) have found that, on average, firms keep their prices unchanged for approximately *3.1 months* using a data set that consists of monthly price observations that are collected only from pazars (bazaars), supermarkets, and bakkals (groceries) across 15 different neighbourhoods of Istanbul. Besides, the time span is very limited, it only covers the period between July 1994 and June 2000. Consistent with the evidence reported in Çağlayan and Filiztekin (2006), Şahinöz and Saraçoğlu (in press), this time using firm level micro data over the period 1988–2006, have showed that, on average, prices remain unchanged for *3.9 months* in Turkey. The data set used by these authors covers only 488 firms and is compiled from the Business Tendency survey (BTS) released by the CBRT. In a previous study, Şahinöz and Saraçoğlu (2008) have analyzed the results of the price-setting survey that was carried out by the Central Bank of the Republic of Turkey (CBRT) between May 2005 and July 2005 on a final sample of 999 firms. Consistent with our results, Şahinöz and Saraçoğlu (2008) have found that the degree of price stickiness in Turkey was much lower than that reported for the euro area[87].

[87] While the median price change was computed as four times a year in Turkey, it was only once a year in the euro area.

The above reported average price durations are lower than that found in our study, but this difference is not surprising since the durations are obtained from very different data sources. We estimate it using an open economy NKPC model applied to aggregate macro data including the CPI, real GDP, terms of trade, real exchange rate, domestic real labor cost and the relative costs of domestic labor and domestically produced intermediate goods, but the others compute it from only micro price observations gathered from firms or vendors.

As for the parameter ω, the estimation results indicate that 73 percent of all firms in Turkey follow the backward looking rule of thumb when setting their prices, implying that inflation inertia in Turkey is fairly high[88]. This value does not change when different specifications of the moment condition are used.

Consistent with our findings, Benigno and Lòpez-Salido (2006) and Céspedes, Ochoa and Soto (2005) have obtained estimates of ω for Italy, Spain and Chile that range from *0.6 to 0.8*. However, Turkey's estimate of ω is found higher than those of U.S and Euro area reported in Galí and Gertler (1999), Galí et al. (2001), Gagnon and Khan (2005), Kurmann (2007), Rumler (2007), Kleibergen and Mavroeidis (2009) and Fanelli and Polomba (in press). These studies report ω in the range between *0.028 and 0.526*. Also when compared to the G-7 countries the estimate of ω is again much higher than the highest estimate of 0.39 found for Italy in Leith and Malley (2007). For South Africa and Mexico, the reported estimates go from. *0.11 to 0.46* and is less than the estimates obtained for Turkey (Plessis and Burger, 2006 and Ramos-Francia and Torres, 2008). These results show that Turkey has experienced a higher degree of backwardness than most of the economies previously mentioned.

This may be associated with Turkey's *unfavorable history of high inflation.* Even though Turkey has adopted first implicit inflation targeting in 2002 and

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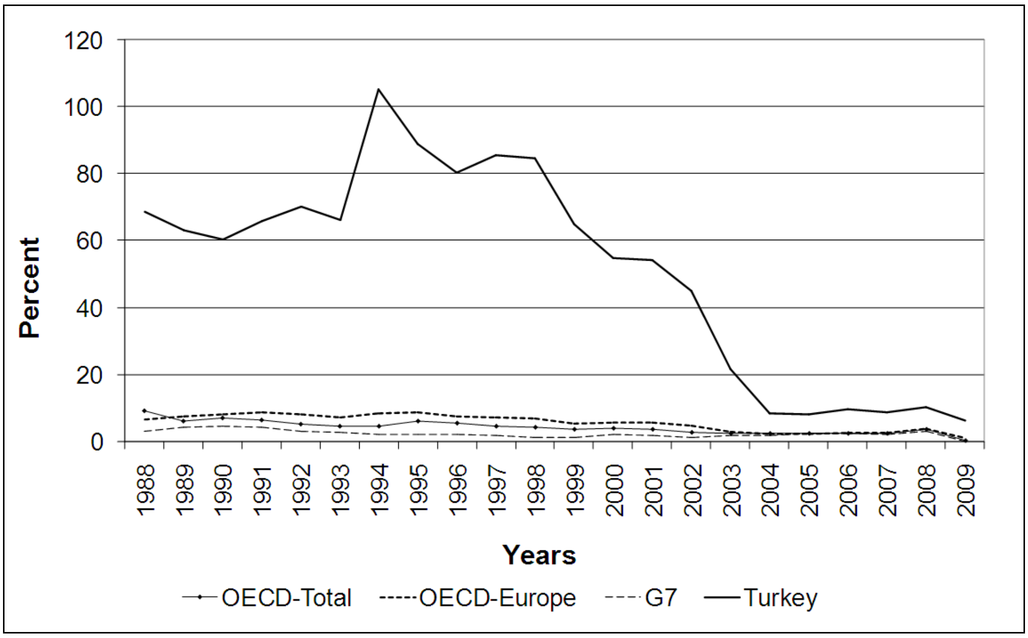
[88] As discussed previously in sections III.B.3 and III.D, the structural parameter ω measures the degree of backwardness in price setting and indicates the degree of intrinsic inflation inertia. Thus, the higher is ω, the higher is the inflation inertia measured by the CPI.

then fully fledged inflation targeting in 2006 to cure its chronic and high inflation after the collapse of the exchange rate based disinflation program supported by the IMF, it still faces inflation that is higher than most of the euro area and G7 countries. Figure 5 plots the evolution of the CPI inflation rate in Turkey, OECD-Europe, OECD-Total and G7 countries for the period 1988-2009. As it can be seen from this figure, inflation in Turkey is significantly higher than that in OECD-Europe, OECD-Total and G7. Fortunately, in the post-2002 period, the inflation rate differential between Turkey and the OECD totals has considerably decreased. Thus, we expect the degree of backwardness to also decrease in Turkey with the economic agents continuing to face this favourable low and stable inflation environment.

Our intuition of modeling the Turkish economy using a hybrid NKPC specification instead of a pure model is supported on empirical grounds with the statistical significance of ω. If we had also estimated a pure NKPC specification as done in Yazgan and Yilmazkuday (2005), it would have been rejected with the high statistically significance of this degree of backwardness parameter, ω. This result gives support for the studies cited in Chapter II which document high inflation inertia in Turkey. However, it lies in stark contradiction to that in Yazgan and Yilmazkuday (2005). Yazgan and Yilmazkuday (2005) have estimated Galí and Gertler's (1999) *closed* economy hybrid NKPC specification and rejected the hybrid model for Turkey on the grounds that the estimate of ω is statistically insignificant and concluded that all firms in Turkey are forward looking. We think that this result of Yazgan and Yılmazkuday (2005) is due to their oversimplifying assumption of modeling the Turkish economy as a closed economy. We have showed in subsection IV.B.6 that the closed economy specification used in Yazgan and Yilmazkuday (2005) does a poor job in explaining the observed inflation dynamics in Turkey. While, the magnitude of the estimate of ω obtained using this closed economy specification decreased significantly, its standard error has increased.



Notes: 2005 is the base year. Zone totals for CPI are annually chain-linked Laspeyres indices. The weights for each individual link are based on the previous year's private final consumption expenditure of Households and Non-profits institution serving Households expressed in purchasing power parity (PPP).

Figure 5 CPI Inflation path over the 1988-2009 period for selected countries and Turkey

Source: OECD (2010)

Celasun (2006) using an open economy NKPC model has also obtained a statistically significant estimate of the parameter ω. On the other hand, while Celasun (2006) finds the estimate of ω significant, she estimates the fraction of backward looking firms approximately 31 percent for Turkey, which is less than one half of our estimate. The relatively high estimate of θ found in Celasun (2006) has translated itself into a low estimate of ω. Since costs involved with backward looking pricing increase when prices once set stay in existence for a much longer period of time, the less frequently are firms able to change their prices (when θ is high) the less will be the fraction following the backward looking price (ω will be low) (Leith and Malley, 2007).

Turning to the other structural parameters, the discount factor β is estimated to be equal to 0.99 in both specifications. Our estimate is in line with other studies and more importantly it is in the range argued by the NKPC theory. According to the NKPC theory, the discount factor should display a value close to 1. As argued in Mihailov et al. (2008), β should theoretically exhibit a magnitude close to 0.99.

The estimate of the degree of openness parameter, γ, seems to be more sensitive to the way orthogonality conditions are specified. The results suggest values of *82 percent* (which represents a home bias of 18 percent) and *59 percent* (a home bias of 41 percent) for specifications 1 and 2, respectively. In Subsection IV.B.7 we have used the *continuous updating GMM* (CU-GMM) estimator, which is robust to the way the orthogonality conditions are normalized, to solve between the conflicting results regarding the normalization used. The estimate of the degree of openness obtained with the CU-GMM estimator is closer to that obtained with the two step GMM estimator for the second specification[89]. Thus, basing our comparison on the result reported by specification 2, the estimate of γ reported for Turkey is found close to those obtained in Mihailov et al. (2008) for ten OECD small economies (including Austria, Germany, Italy, France, Spain, Netherlands, U.K., Canada, Sweden and Switzerland). Reported estimates of this parameter range from *14 to 48* percent for those countries.

The elasticity of substitution between inputs ρ takes a value of *-6.2* in both specifications. This estimate is consistent with those found in Rumler (2007) for euro area countries and Leith and Malley (2007) for the G7. Reported estimates in these studies range from *-17.6 to 10.8*. We tested whether assuming a Cobb–Douglas production technology (i.e. ρ = 1) or a Leontief production technology (i.e. ρ = 0) would as well fit the Turkish data. We tested both hypotheses using the GMM extensions of the Lagrange Multiplier (LM)

[89] Section IV.B.7 shows that the same result continues when other two step estimates are compared with their CU-GMM counterparts.

and Likelihood Ratio (LR) tests discussed in subsection IV.B.2.2.ii and given in equations (4.11) and (4.12), respectively[90]. Table 2 contains the LM and D statistics for the null hypotheses $\rho = 1$ and $\rho = 0$ under specifications 1 and 2. For Turkey, we highly reject both the Cobb–Douglas production technology and the Leontief production technology at conventional significance levels.

Table 2 Test Statistics for Cobb–Douglas production technology (i.e. $\rho = 1$) and Leontief production technology (i.e. $\rho = 0$)

	Specification 1		**Specification 2**	
	H_0: $\rho = 1$	**H_0: $\rho = 0$**	**H_0: $\rho = 1$**	**H_0: $\rho = 0$**
LM	50169 (0.0000)	46993 (0.0000)	22805 (0.0001)	44237 (0.0000)
D	50169 (0.0000)	46992 (0.0000)	22807 (0.0000)	44237 (0.0000)

Notes:
[a]The p-value of the tests are given in parentheses.
[b] Both test statistics converge to a χ_1^2 distribution (Hall, 2005, pp. 163-164).
Source: Author's own calculations

IV.B.3.2 Reduced form Parameters

Results obtained for the reduced form coefficients in Table 1 reveal that the estimate of the backward looking coefficient of inflation is found statistically significant and quantitatively higher than the forward looking coefficient. Since the reduced form coefficients are calculated from the estimates of the structural form parameters, the predominance of the forward looking behaviour results

[90] All the tests are computed using MATLAB 7.0.4.

from estimating the degree of backwardness higher than the degree of price stickiness. As argued above, this result occurs because the costs involved with backward looking pricing decrease when prices once set is expected to stay in existence for a relatively shorter period of time. Thus, the more frequently are firms able to change their prices (when θ is low) the more will be the fraction following the backward looking price (ω will be high).

When compared to other Turkish NKPC studies, in contrast to Yazgan and Yılmazkuday (2005) and Celasun et al. (2004a) who have find that inflation is solely determined by forward looking behaviour and Celasun (2006) and Celasun et al. (2004b) who estimate the forward looking component to be quantitatively more important than the backward looking component, our estimates suggest that inflation in Turkey is still predominantly *backward looking*.

In Subsection IV.B.6, we have showed that inflation becomes predominantly forward looking as one moves from open economy specifications to closed economy specification. Thus, this is the reason behind the conflicting evidence reported in Yazgan and Yilmazkuday (2005). In case of Celasun (2006), the predominance of forward looking behaviour stems from estimating the degree of backwardness lower than the degree of price stickiness. Finally, the difference between our results and those reported in Celasun et al. (2004a, 2004b) may result from these studies having estimated the linear reduced form of the NKPC directly (without imposing any restrictions on the coefficients of these terms). These studies have thereby neglected to take into account the connection between the structural parameters of the model and the reduced form parameters that they estimate.

As discussed in Chapter II, for other countries, the evidence on the forward versus backward looking behaviour debate is rather mixed. Using a *closed economy* model for U.S. and the euro area Fuhrer and Moore (1995), Fuhrer (1997), Lindѐ (2005), Rudd and Whelan (2005a) and Paloviita (2006) have found that backward looking behavior dominates the forward looking behavior in determining the inflation process, while Galí and Gertler (1999), Sbordone (2002, 2005), Galí et al. (2001), Gagnon and Khan (2006) have found the opposite. On the other hand using *open economy* models, Benigno and Lòpez-Salido (2006) and Hondroyiannis, Swamy and Tavlas (2009) have refuted the dependence of current inflation process on future inflation for Spain, France, Germany, U.K. and Italy using again open economy models. However, Rumler (2007), Holmberg (2006), and Batini et al. (2005) have concluded that forward looking is quantitatively more important than backward looking behaviour for the Euro area countries, Sweden and U.K.

Turning to the parameters of real marginal cost and the LOOP gap, we see that their estimated coefficients are statistically significant although quantitatively small effects are obtained. The results reported for the parameter λ_{mc} are slightly below those obtained for the euro area countries where it is estimated between *0.012 and 0.186*, and equal to that reported for Mexico where the coefficient of marginal cost equals *0.006*. For the euro area total and the U.S, the estimate of the marginal cost term fluctuates in the range between 0.006 and *0.291* and is consistent with the evidence that we have reported.

VI.B.4 Fundamental Inflation – Fit of the NKPC

In this subsection we will analyze how well our model fits the *observed* inflation dynamics in Turkey. To do so, we have followed the approach initiated by Galí and Gertler (1999) and Galí et al. (2001) and constructed a model based measure of inflation called *fundamental inflation*. This is done by first solving the NKPC equation that is in the form of a second order difference equation and then replacing the unknown expectational terms appearing in this equation with multiperiod forecasts generated from a Vector Autoregression (VAR) model. Then, this model based measure of inflation is compared with actual inflation using three different measures of fit. Before presenting these results, first, in the upcoming subsection we have defined the fundamental inflation and showed how to construct it in the context of our NKPC model.

IV.B.4.1 Derivation

To derive the fundamental inflation implied by our NKPC model, start by writing the NKPC equation in the following inexact reduced form (see Chapter III equation (3.140))[91]:

$$\pi_t = \gamma_f E\left[\pi_{t+1} \mid \Omega_t\right] + \gamma_b \pi_{t-1} + \lambda_{mc} mc_t + \lambda_{loopgap} \psi_{F,t} + \varepsilon_t \qquad (4.13)$$

Then, assume that the econometrician observes only a subset $\omega_t = \left[Z_t \, Z_{t-1} .. Z_{t-(p-1)}\right]'$ of the agents' information set Ω_t where $Z_t = \left[z_{1t} \, z_{2t} .. z_{nt}\right]'$ is an *n-variable* vector of information available at date *t* but not at *t-1*. Also assume that the econometrician forecasts agents' expectations for mc_t, $\psi_{F,t}$ and π_t with a VAR(*p*) process written in companion form as $\omega_t = M \omega_{t-1} + e_t$, where mc_t, $\psi_{F,t}$ and $\pi_t \in Z_t$ and $\left[e_t e'_{t+k}\right] \sim \left[0, \Sigma\right]$ with $\Sigma = 0$ for all $k \neq 0$. Furthermore, assume ε_t to be uncorrelated with ω_{t-1}.

Using these assumptions, equation (4.13) can be rewritten as:

$$\pi_t = \left[\gamma_f E\left[\pi_{t+1} \mid \omega_t\right] + \gamma_b \pi_{t-1} + \lambda_{mc} mc_t + \lambda_{loopgap} \psi_{F,t}\right] + \varepsilon_t + \zeta_t \qquad (4.14)$$

where the term $\zeta_t = \gamma_f \left\{E\left[\pi_{t+1} \mid \Omega_t\right] - E\left[\pi_{t+1} \mid \omega_t\right]\right\}$ appears because the econometrician uses only a subset of the agents' full information set, i.e. $\omega_t \subseteq \Omega_t$.

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[91] Throughout this section, we follow the notation used by Kurmann (2005).

The term in square brackets is defined as fundamental inflation and denoted by π_t^*. Under the null hypothesis that the NKPC model is true, equation (4.14) holds *exactly* so that fundamental inflation equals the observed rate of inflation;

$$\pi_t = \left[\gamma_f E\left[\pi_{t+1} \mid \omega_t \right] + \gamma_b \pi_{t-1} + \lambda_{mc} mc_t + \lambda_{loopgap} \psi_{F,t} \right] \equiv \pi_t^* \tag{4.15}$$

Thus, under the null hypothesis it is assumed that π_t contains all information that markets use to forecast marginal cost and the LOOP gap (Kurmann, 2005). This implies that, as long as $\pi_t \in \omega_t$, ω_t should contain all the relevant information to forecast future marginal cost and LOOP gap so that ω_t corresponds to the full information set Ω_t (i.e. $\zeta_t = 0$). On the other hand, under the alternative hypothesis that the model does not hold exactly, π_t no longer contains all the necessary information to forecast the real marginal cost and the LOOP gap. Thus, in this case, ω_t becomes only a subset of the full information set, i.e. $\omega_t \subseteq \Omega_t$ (i.e. $\zeta_t \neq 0$) and equation (4.15) no longer holds. An implication of this is that π_t^* can be used to measure how well our NKPC model fits the observed inflation dynamics. To the extent that our open economy hybrid NKPC model is true, fundamental inflation should closely mimic the behavior of actual inflation.

Under the assumption that the model is true, a measure of fundamental inflation, π_t^*, is constructed by solving the second order difference equation in equation (4.15) using Sargent's factorization method. Thus, the first step in this method is to take expectations of the entire equation based on the oldest information set, ω_t:

$$\pi_t = \gamma_f E\left[\pi_{t+1} \mid \omega_t \right] + \gamma_b \pi_{t-1} + X_t \tag{4.16}$$

where to ease the notation, we have denoted $\lambda_{mc} mc_t + \lambda_{loopgap} \psi_{F,t}$ by X_t. Then equation (4.16) is written in terms of lag and forward operators as:

$$\pi_t = \gamma_f FE[\pi_t \mid \omega_t] + \gamma_b L\pi_t + X_t \tag{4.17}$$

and the terms involving π_t are collected to obtain

$$(-\gamma_f F - \gamma_b L + 1)E[\pi_t \mid \omega_t] = X_t \tag{4.18}$$ [92]

or upon dividing through by $-\gamma_f$,

$$(F + \frac{\gamma_b}{\gamma_f} L - \frac{1}{\gamma_f})\pi_t^* = -\frac{1}{\gamma_f} X_t \tag{4.19}$$

By taking into the parenthesis of L and noting that $L^{-2}.L \equiv L^{-1}$, $L^{-1}.L \equiv 1$, and $L^{-n}.y_t \equiv F^n y_t$, rewrite the term in brackets in equation (4.19) as follows:

$$\left(L^{-1} + \frac{\gamma_b}{\gamma_f} L - \frac{1}{\gamma_f} LL^{-1} \right) = \left(L^{-2} + \frac{\gamma_b}{\gamma_f} - \frac{1}{\gamma_f} L^{-1} \right) L = \left(F^2 + \frac{\gamma_b}{\gamma_f} - \frac{1}{\gamma_f} F \right) L \tag{4.20}$$

Then, using equation (4.20), rewrite (4.19) in the following form:

$$\left(F^2 + \frac{\gamma_b}{\gamma_f} - \frac{1}{\gamma_f} F \right) L\pi_t = -\frac{1}{\gamma_f} X_t \tag{4.21}$$

or

[92] Note that $\pi_t = E[\pi_t \mid \omega_t]$ $L\pi_t = LE[\pi_t \mid \omega_t]$.

$$\left(F-\delta_1\right)\left(F-\delta_2\right)L\pi_t=-\frac{1}{\gamma_f}X_t \tag{4.22}$$

where

$$\delta_1\delta_2=\frac{\gamma_b}{\gamma_f} \text{ and } \delta_1+\delta_2=\frac{1}{\gamma_f} \tag{4.23}$$

From (4.23) we can solve for $\{\delta_1,\delta_2\}$ in the following form

$$\{\delta_1,\delta_2\}=\frac{1}{2}\left[\frac{1}{\gamma_f}\mp\sqrt{\left(\frac{1}{\gamma_f}\right)^2-4\frac{\gamma_b}{\gamma_f}}\right]=\frac{1\mp\sqrt{1-4\gamma_b\gamma_f}}{2\gamma_f} \tag{4.24}$$

where the values of δ_1 and δ_2 depend on the values of the parameters of the model. We will assume that, $0<\delta_1<1<\delta_2$, so that δ_1 is the stable root and δ_2 is the unstable one, which turns out to be the assumption necessary for a saddle-path stable solution[93]. Thus, (4.22) can be solved as follows:

$$\left(F-\delta_1\right)L\left(F-\delta_2\right)\pi_t=-\frac{1}{\gamma_f}X_t$$

$$\left(FL-\delta_1L\right)\left(F-\delta_2\right)\pi_t=-\frac{1}{\gamma_f}X_t$$

$$\left(L^{-1}L-\delta_1L\right)\left(F-\delta_2\right)\pi_t=-\frac{1}{\gamma_f}X_t$$

[93] Our estimates of γ_f and γ_b imply the existence of one stable and one unstable root associated with the stationary solution to the NKPC equation given by equation (3.140).

$$\left(1-\delta_1 L\right)\left(F-\delta_2\right)\pi_t = -\frac{1}{\gamma_f} X_t$$

$$\left(1-\delta_1 L\right)\pi_t = -\frac{1}{\gamma_f}\left(F-\delta_2\right)^{-1} X_t$$

$$\left(1-\delta_1 L\right)\pi_t = -\frac{1}{\gamma_f}\left[-\delta_2\left(1-\frac{F}{\delta_2}\right)\right]^{-1} X_t$$

$$\left(1-\delta_1 L\right)\pi_t = -\frac{1}{\gamma_f}\left[-\delta_2\left(1-\delta_2^{-1}F\right)\right]^{-1} X_t$$

$$\left(1-\delta_1 L\right)\pi_t = \frac{1}{\gamma_f \delta_2}\left(1-\delta_2^{-1}F\right)^{-1} X_t \tag{4.25}$$

Since $0 < \delta_2^{-1} < 1$, we can expand the right hand side of equation (4.25) into the following convergent series

$$\left(1-\delta_2^{-1}F\right)^{-1} = \sum_{i=0}^{\infty} \delta_2^{-i} F^i \tag{4.26}$$

so that

$$\pi_t - \delta_1 \pi_{t-1} = \frac{1}{\gamma_f \delta_2}\sum_{i=0}^{\infty} \delta_2^{-i} F^i X_t \tag{4.27}$$

or

$$\pi_t = \delta_1 \pi_t + \frac{1}{\gamma_f \delta_2}\sum_{i=0}^{\infty} \delta_2^{-i} E_t\left(X_{t+i}\right) \tag{4.28}$$

Remember that $X_t = \lambda_{mc} mc_t + \lambda_{loopgap} \psi_{F,t}$ so that $X_{t+i} = \lambda_{mc} mc_{t+i} + \lambda_{loopgap} \psi_{F,t+i}$. Thus, using equation (4.28), the solution to the second order difference equation can be obtained in the following form;

$$\pi_t = \delta_1 \pi_{t-1} + \frac{1}{\gamma_f \delta_2} \left\{ \sum_{i=0}^{\infty} \delta_2^{-i} \left[\lambda_{mc} E_t \left(mc_{t+i} \right) + \lambda_{loopgap} E_t \left(\psi_{F,t+i} \right) \right] \right\} \tag{4.29}$$

In Equation (4.29), multiperiod forecasts of real marginal cost and loop gap (conditional on information ω_t observable by econometrician) can be written as:

$$E\left[mc_{t+i} \mid \omega_t \right] = e'_{mc} M^i \omega_t \tag{4.30}$$

and

$$E\left[\psi_{F,t+i} \mid \omega_t \right] = e'_{LG} M^i \omega_t \tag{4.31}$$

where e_{mc} and e_{LG} are selection vectors that single out the forecasts for real *mc* and loop gap. Substitute the expressions given above into equation (4.29) to obtain;

$$\pi_t = \delta_1 \pi_{t-1} + \frac{\lambda_{mc}}{\gamma_f \delta_2} \left[e'_{mc} \omega_t + \delta_2^{-1} e'_{mc} M \omega_t + \delta_2^{-2} e'_{mc} M^2 \omega_t + \ldots \right]$$

$$+ \frac{\lambda_{loopgap}}{\gamma_f \delta_2} \left[e'_{LG} \omega_t + \delta_2^{-1} e'_{LG} M \omega_t + \delta_2^{-2} e'_{LG} M^2 \omega_t + \ldots \right]$$

$$\pi_t = \delta_1 \pi_{t-1} + \frac{\lambda_{mc}}{\gamma_f \delta_2} e'_{mc} \left[I + \delta_2^{-1} M + \delta_2^{-2} M^2 + \ldots \right] \omega_t$$

$$+\frac{\lambda_{loopgap}}{\gamma_f \delta_2} e'_{LG} \left[I + \delta_2^{-1} M + \delta_2^{-2} M^2 + \ldots \right] \omega_t$$

$$\pi_t = \delta_1 \pi_{t-1} + \frac{\lambda_{mc}}{\gamma_f \delta_2} e'_{mc} \left(I - \frac{1}{\delta_2} M \right)^{-1} \omega_t + \frac{\lambda_{loopgap}}{\gamma_f \delta_2} e'_{LG} \left(I - \frac{1}{\delta_2} M \right)^{-1} \omega_t \equiv \pi_t^* \qquad (4.32)$$

Equation (4.32) represents the equation describing the model based measure of inflation.

As argued in Galí et al. (2001), equation (4.15) is only a good first approximation and cannot be expected to hold exactly in reality. Then the question is how well our model based measure of fundamental inflation can track the actual inflation developments. Thus, in the next subsection we will use this equation to construct the fundamental inflation series implied by our model and then compare the resultant series with actual inflation.

IV.B.4.2 Comparison of Fundamental Inflation with Actual Inflation

The multiperiod forecasts of marginal cost and LOOP gap given in equations (4.30) and (4.31) are computed from a three-variate VAR in marginal cost (MC), LOOP gap (LOOPGAP) and CPI inflation (INF). Following Galí and Gertler (1999), Kurmann (2005, 2007) and Fanelli (2008) we have specified the VAR model in terms of only the independent and dependent variables of the reduced form NKPC equation.

For the two sets of results based on two different specifications of the orthogonality conditions, two different marginal cost and LOOP gap series are calculated. As a result, two different VAR models are estimated with the deterministic part of each VAR given by a constant term. Before estimating the VARs, each marginal cost and LOOP gap series is pretested for stationarity using the conventional ADF test. The lag length for the ADF test is chosen as outlined in subsection IV.B.2. The test results are shown in Table A.2 at the

Appendix section. For all the series, the null hypothesis of a unit root is rejected at 1% significance level. The order of the VAR model is determined using the multivariate generalizations of AIC and SIC, and by conducting lag exclusion (Wald) tests. At the lag for which at least two of the above criteria have agreed upon, we have tested whether the residuals exhibit serial correlation and/or heteroscedasticity.

In case of specification 1, while the lag length tests indicated a VAR(4) model, one more lag was added to avoid serial correlation present in the residuals of the VAR(4) model. Thus, for specification (1) a VAR(5) model was chosen. On the other hand, for specification 2, a VAR(4) model was sufficient to remove any serial correlation or heteroscedasticity present in the residuals. Table A.3 in the Appendix reports the diagnostic test results conducted on the residuals of the VAR models and Tables A.4 and A.5 present the OLS estimates of the estimated VAR models.

Using the VAR coefficients reported in Tables A.4 and A.5 to construct the companion matrix *M*, the fundamental inflation series is calculated from equation (4.32). Figures 6 and 7 plot the fundamental inflation series based on specifications 1 and 2 (denoted with SP1 and SP2, respectively) and compare their performance in tracking the actual inflation behaviour in Turkey for the period 1989 to 2009. The results are striking: For the period under consideration the inflation series based on both specifications give a good representation of the actual inflation developments in Turkey. In particular, they seem successful in explaining both the 1994 and 2000-01 crises as well as the current environment of low inflation achieved with the adoption of the implicit and fully fledged inflation targeting regimes. Both of the fundamental inflation series seem to deviate less from actual inflation after the 2002 period with Turkey adopting the implicit inflation targeting regime and thus, in general, experiencing less volatile inflation[94]. The fit of fundamental inflation

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[94] See section IV.B.8.1 for details.

is even better than that in Galí and Gertler (1999) and Galí et al. (2001) reported for the U.S. and the Euro area.

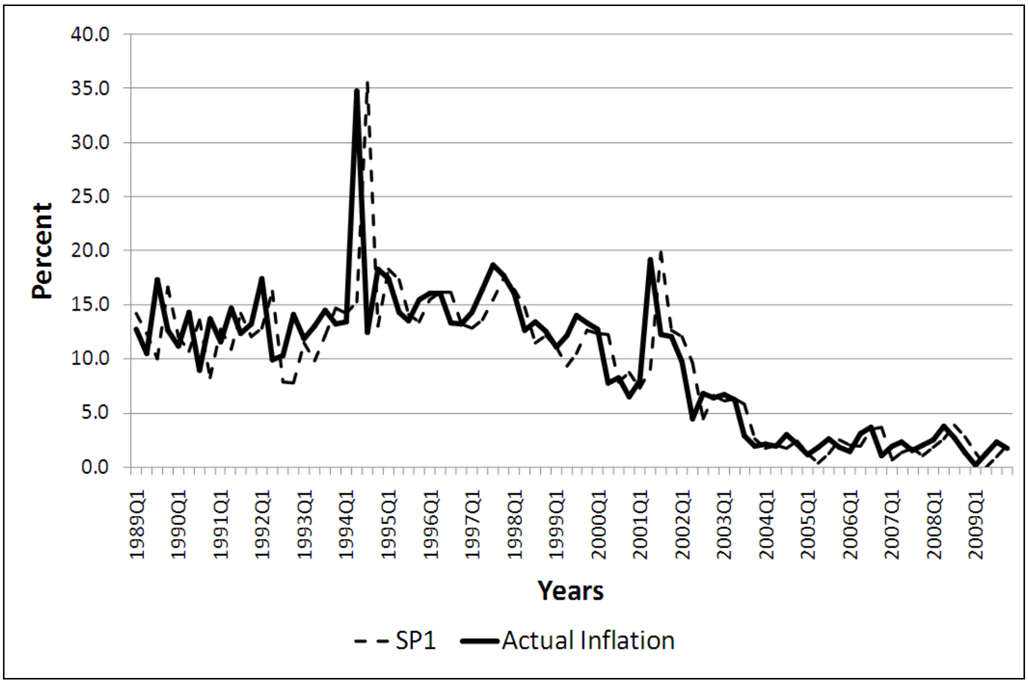

Figure 6 Fundamental Inflation Series based on Specification 1 and Actual Inflation

Source: Author's own calculations

A simple visual inspection of Figures 6 and 7 does not give a precise decision on which fundamental inflation series (SP1 or SP2) does a better job in tracking actual inflationary developments in Turkey. Therefore, to decide which specification better explains the actual inflation behaviour in Turkey, we have compared the two fundamental inflation series ($\pi^*_{t,i}$ where *i*=1, 2 refers to specifications 1 and 2) using *three measures of fit*: *Ratio of the standard deviations* of fundamental inflation to actual inflation calculated for each specification ($SD(\pi^*_{t,i},\pi_t)=\sigma(\pi^*_{t,i})/\sigma(\pi_t)$ for i=1,2), *the correlation coefficient* between fundamental inflation and actual inflation calculated for each specification ($CORR(\pi^*_{t,i},\pi_t)$ for i=1,2) and *root mean square deviation* of fundamental inflation from actual inflation calculated for each specification ($RMSE(\pi^*_{t,i},\pi_t)=\sqrt{\sum_{t=1}^{T}(\pi^*_{t,i}-\pi_t)^2/T}$ for i=1,2).

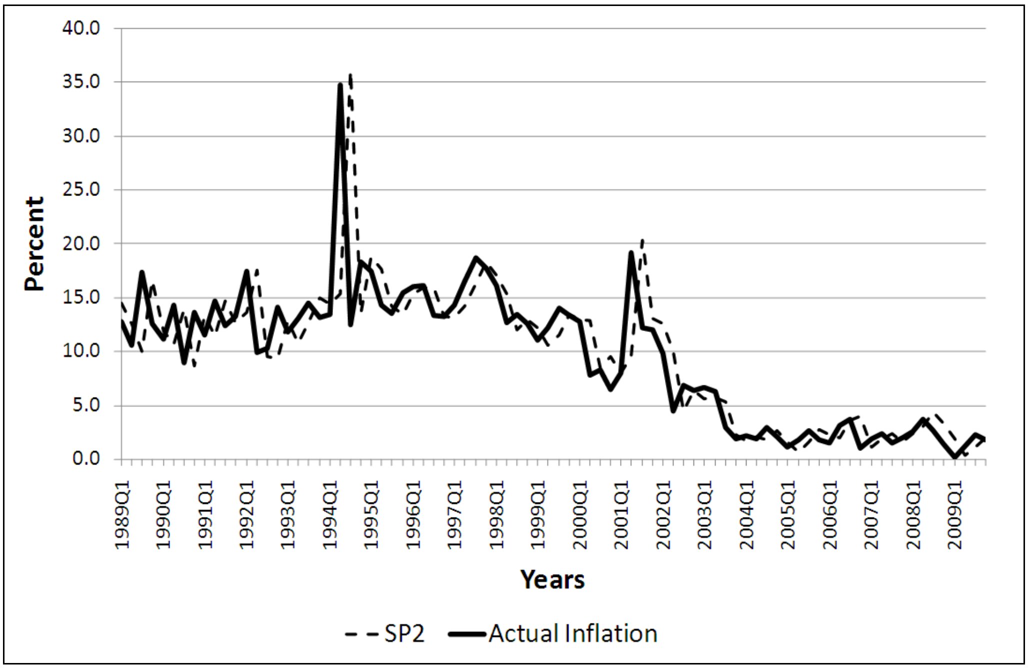

Figure 7 Fundamental Inflation Series based on Specification 2 and Actual Inflation

Source: Author's own calculations

Direct implications of equation (4.15) are that under the null hypothesis that the model is true, observed inflation and theoretical inflation should be perfectly correlated, have the same standard deviation and the root mean square deviation between the two series should be zero. However, as mentioned before, in reality this equation cannot hold exactly, implying that π_t^* can only represent an approximation of the observed inflation process. Therefore, for fundamental inflation to be a good approximation of actual inflation process, the ratio of the standard deviations of the two series should be close to one, the correlation between the two series should be close to one and the root mean square error should be close to zero.

To penalize fundamental inflation series having a higher standard deviation then the actual inflation series and also the opposite, first we subtracted $SD(\pi_t^*, \pi_t)$ from 1 and then took its absolute value. Thus, the absolute standard deviations of the two series, which have denoted by $ASD(\pi_{t,i}^*, \pi_t)$, ($ASD(\pi_{t,i}^*, \pi_t) = ABSOLUTE\ VALUE(1-(SD(\pi_{t,i}^*, \pi_t))$ for i=1,2) should be close to zero rather than one.

Table 3 gives the three measures of fit and ranks the specifications' performance according to these measures. The fundamental inflation series with the lowest absolute standard deviation ($ASD(\pi_t^*, \pi_t)$), highest correlation coefficient ($CORR(\pi_t^*, \pi_t)$) and lowest root mean square deviation ($RMSE(\pi_t^*, \pi_t)$) is ranked as 1 and the other as 2. Then, the mean ranking score that the series get from these three criteria is calculated and given in the last column. According to these results, specification 2 given in equation (4.4) has a higher explanatory power than specification 1 given in equation (4.4). Also Galí and Gertler (1999), constructing two different fundamental inflation series based on their different specifications of the moment conditions, have preferred specification 2 which does not normalize the coefficient of inflation to unity over specification 1.

Table 3 Measures of fit to compare specifications 1 and 2 based on fundamental inflation series

	$ASD(\pi_t^*, \pi_t)$	$CORR(\pi_t^*, \pi_t)$	$RMSE(\pi_t^*, \pi_t)$	**Rank**
Specification 1	0.0107	0.7610	0.0432	**2**
Specification 2	0.0004	0.7650	0.0430	**1**

Source: Author's own calculations

IV.B.5 Comparison across Alternative Models

In the previous subsection we evaluated our models performance in terms of its ability to explain the observed inflation dynamics in Turkey and saw that it tracked the actual inflation behaviour quite well. Now, we will show that this good fit is not just a mere coincidence and continues when our model is compared with two other alternatives: *a closed economy model* employing only labor and an *open economy model* without imported intermediate goods (thus, employing both labor and domestically produced intermediate inputs).

These two variations were especially chosen to investigate whether the two model features discussed in Chapter II (openness and production technology incorporating imported intermediate inputs) did really improve the validity of our results. Thus, we will not only compare our models performance with these two alternatives but also try to validate the importance of building an open economy model with imported intermediate inputs for Turkey. Basically, we will show that our open economy model that incorporates both domestically produced and imported intermediate inputs into the production function explains the inflation dynamics in Turkey better than do the other two models, with the closed economy specification performing worse than the open economy specification without imported intermediate inputs.

Our model with both imported and domestically produced intermediate inputs (denoted by OEM2) nests both the closed economy specification and the open economy specification without imported intermediate inputs. Using equation (4.2a), the closed economy model with only labor used in the production process (denoted by CEM), can be obtained by setting the share of imported final goods in the domestic consumption basket (γ) to zero and assuming that no domestically produced or imported intermediate goods are used in the production process (i.e., the share of imported intermediate goods in GDP, $\overline{s}_{M_F}$, and their weight in the production function, α_F, are set to zero. Also the share of domestically produced intermediate goods in GDP, $\overline{s}_{M_H}$, and their weight in the production function, α_H, are set to zero). The CEM obtained in this way corresponds to the closed economy hybrid NKPC specification (with only labor used in the production) widely employed in the literature (equation 2.5 given in Chapter II). The open economy model without imported intermediate inputs (denoted by OEM1) can be obtained by setting only the share of imported intermediate goods in GDP, $\overline{s}_{M_F}$, and their weight in the production function, α_F, to zero. Thus, in OEM1, unlike our model, trade takes place only at the final goods level.

IV.B.5.1.Estimation Results

CEM and OEM1 are estimated using the two step GMM estimator. The estimates of the structural and reduced form parameters are reported in Table 4. The estimates are again obtained for two different normalizations of the moment conditions: according to specification 1 that does normalize the coefficient of inflation to unity (i.e. equation 4.4) specification 2 that does not (i.e. equation 4.5 - specification 2). The instrument set includes a constant term and four lags of domestic price inflation, growth rate of USD-TL exchange rate and ratio of wages to domestic prices (i.e., $w_t - p_{H,t}$) for CEM[95]. In estimating OEM1 the instruments used are a constant term and four lags of domestic price inflation, CPI inflation, growth rate of USD-TL exchange rate and ratio of wages to domestic prices (i.e., $w_t - p_{H,t}$). The last four rows give the average duration of prices measured in months (denoted with D) and *p-values* of Hansen's test of overidentifying restrictions (J-test), Anderson and Rubin (1949) test (AR-test) and the Kleibergen test (K-test).

When we analyze Table 4, first thing to note is that all the estimated reduced and structural parameters have correct signs, are in the theoretically expected range. The structural parameters in both CEM and OEM1 are statistically significant, again in most cases at the 1 percent significance level. However, when compared to OEM2 (Table 1), the slope coefficient estimates in Table 4 (either one or both of the coefficients of marginal cost and LOOP gap for OEM1 and the coefficient of marginal cost for CEM) are found to be statistically insignificant. Thus, if delivering statistically significant coefficient estimates is regarded as a ground to evaluate the three models, OEM2 can be preferred to both CEM and OEM1.

[95] As Zhang et al. (2009) states, an important problem that is usually overlooked when using the lags of the dependent variable as instruments, is the possible presence of serial correlation in the NKPC equation. All lags of the dependent variable are invalid instruments in the presence of serial correlation. Following Zhang et al. (2009) to take this possibility into account, we conducted a *non parametric* serial correlation test (Geary Sign – Change test (Geary, 1970)) on the residuals of the CEM in case of both specifications. A non parametric test is applied since to our knowledge no serial correlation test has been developed within the context of the GMM estimator. The results are reported in Table 4 and show no evidence of serial correlation present in the residuals.

Table 4 GMM estimates of the reduced and structural form parameters for CEM and OEM1

Estimates of Structural Parameters[a]				
	CEM		OEM1	
	Specification 1	**Specification 2**	**Specification 1**	**Specification 2**
$\boldsymbol{\theta}$	0.801*** (0.056)	0.862*** (0.093)	0.527** (0.231)	0.430*** (0.118)
$\boldsymbol{\beta}$	0.999*** (0.000)	0.990*** (0.000)	0.992*** (0.014)	1.00*** (0.007)
$\boldsymbol{\omega}$	0.268* (0.149)	0.232* (0.136)	0.746*** (0.021)	0.720*** (0.014)
$\boldsymbol{\rho}$	----	----	-4.054*** (0.170)	-5.093*** (0.894)
$\boldsymbol{\gamma}$	----	----	0.039*** (0.006)	0.174* (0.094)
D	15.11	21.82	6.34	5.26
J-test	0.218	0.058	0.840	0.995
GS-test	0.4214	0.4654	0.1616	0.6100
Estimates of Reduced Form Parameters[b]				
γ_f	0.750*** (0.106)	0.781*** (0.076)	0.411*** (0.107)	0.376*** (0.064)
γ_b	0.250** (0.106)	0.212*** (0.077)	0.588*** (0.107)	0.625*** (0.064)
λ_{mc}	0.004 (0.004)	0.002** (0.001)	0.024 (0.028)	0.036* (0.019)
$\lambda_{loopgap}$	----	----	0.002 (0.002)	0.014 (0.010)

Notes:
[a] The first part of this table presents the two-step GMM estimates of the structural form coefficients where the nonlinear two stage least squares estimator provides the initial consistent estimator.
[b] The second part of this table presents the implied estimates of the reduced form parameters calculated from equation (3.140) and their calculated standard errors. The standard errors of the reduced form parameters are computed according to Kmenta (1986).
[c] Asterisks (***,**,*) denote statistical significance at 1% , 5% and 10% levels, respectively.
[d] D denotes average price duration measured in months. See footnote 82 in text.
[e] GS denotes the p-value of the Geary Sign – Change serial correlation test (Geary, 1970). See footnote 95.
[f] The figures in parentheses are standard errors.
Source: Author's own calculations

Second, in general, the estimates of reduced and structural form parameters are robust to different specifications of the moment conditions. Third, Hansen's J-test statistics reported in Table 4 do not reject the null hypothesis that the overidentifying moment conditions are valid and supported by the data.

Before comparing the estimates of structural parameters θ and ω and reduced form parameters γ_f and γ_b among the three models, which are the parameters commonly estimated in all three models, let us in the next section investigate which model is better suited for studying inflation dynamics in Turkey[96].

IV.B.5.2 Identifying the model with the best fit

To understand which of the three model specifications is able to explain the observed inflation dynamics in Turkey better than the others, we have employed the concept of fundamental inflation introduced in the previous subsection. We have constructed two different fundamental inflation series for CEM and OEM1 based on the estimates obtained from the two different normalizations of the moment conditions (specifications 1 and 2).

While in case of CEM, the forecasts of marginal cost are computed from a bivariate VAR in marginal cost and CPI inflation, for OEM1 forecasts of marginal cost and LOOP gap are computed from a three-variate VAR in marginal cost, LOOP gap and CPI inflation. Each VAR model is estimated with the deterministic part given by a constant term. Prior to estimation, first each of the calculated marginal cost and LOOP gap series is tested for the presence of unit root using the conventional ADF test. The results of these tests are reported in Table A.6 at the Appendix section. An inspection of this table shows that for most of the series, the null hypothesis of a unit root is rejected at 1% significance level. Second, the order of the VAR model is determined using

[96] The structural parameter β is estimated very close to one in all three models and therefore its estimates will not be compared among the three models. The coefficient of marginal cost (λ_{mc}) somehow seems to be estimated imprecisely in both CEM and OEM1 (its estimate is reported to be insignificant in specification 1 of both models) and for this reason its estimates will also not be compared among the alternating models.

the AIC, SIC, by conducting lag exclusion (Wald) tests and looking at the residual diagnostics. The residual diagnostics are presented in Tables A.7 and A.8 in the Appendix section. In case of the CEM, the criteria have pointed to a VAR model of order 6 and 4 for specifications 1 and 2, respectively. On the other hand, for the OEM1, looking at the residual diagnostic tests a VAR model of order 6 was selected in both specifications. Tables A.9-A.11 report the OLS estimates of the estimated VAR models.

The fundamental rates of inflation obtained from each model, based on the two different specifications, are compared with the actual rate of inflation by calculating the aforementioned measures of fit. Namely, the absolute value of the ratio of the standard deviation of the fundamental inflation series to actual inflation ($ASD(\pi^*_{t,i}, \pi_t) = ABSOLUTE\ VALUE(1-(SD(\pi^*_{t,i}, \pi_t))$ for *i*=CEM under specification 1, CEM under specification 2, OEM1 under specification 1, OEM1 under specification 2, OEM2 under specification 1 and OEM2 under specification 2), the correlation coefficient between the two series ($CORR(\pi^*_{t,i}, \pi_t)$ for *i*= *i*=CEM under specification 1, CEM under specification 2, OEM1 under specification 1, OEM1 under specification 2, OEM2 under specification 1 and OEM2 under specification 2) and root mean square deviation of fundamental inflation from actual inflation ($RMSE(\pi^*_{t,i}, \pi_t) = \sqrt{\sum_{t=1}^{T} (\pi^*_{t,i} - \pi_t)^2 / T}$ for *i*=CEM under specification 1, CEM under specification 2, OEM1 under specification 1, OEM1 under specification 2, OEM2 under specification 1 and OEM2 under specification 2). Then, we have ranked the model and specification pair with the lowest absolute standard deviation, highest correlation coefficient and lowest root mean square deviation as 1. The other model and specification pairs are ranked accordingly, getting the ranking scores 2, 3, etc., respectively. Finally, the mean ranking score that each model gets from these three criteria is calculated and given in Table 5.

Table 5 Measures of fit to compare CEM, OEM1 and OEM2 based on fundamental inflation series

	$ASD(\pi_t^*, \pi_t)$	$CORR(\pi_t^*, \pi_t)$	$RMSE(\pi_t^*, \pi_t)$	**Ranking Scores**	**Rank**
CEM (Specification 1)	0.7130	0.706	0.0868	5.7	6
CEM (Specification 2)	0.7306	0.742	0.0867	5.3	5
OEM1 (Specification 1)	0.0127	0.7582	0.0435	3.7	4
OEM1 (Specification 2)	0.0029	0.7597	0.0437	3	3
OEM2 (Specification 1)	0.0107	0.7610	0.0432	2.3	2
OEM2 (Specification 2)	0.0004	0.7650	0.0430	1	1

Note: Last two rows are taken from Table 3.
Source: Author's own calculations

Table 5 shows that our most general model specification, OEM2, which employs labor, imported and domestically produced intermediate goods in the production process, whether estimated based on specification 1 or 2, does a better job in explaining actual inflation developments in Turkey than both the closed economy model with only labor (CEM) and the open economy model without imported intermediate goods (OEM1). Averaging the ranking scores across specifications 1 and 2 for each model, gives a score of 1.7 for OEM2, 3.3 for OEM1 and 5.5 for CEM. Thus, OEM2 is followed by the open economy model without imported intermediate goods (OEM1) and the closed economy model (CEM) appears to be the last in this raking. This particular evidence shows that openness and the inclusion of imported intermediate goods significantly improves the validity of our results. Furthermore, Table 5 shows that uniformly in all models, specification 2 outperforms specification 1. Thus, we can conclude that for all three models considered in this study, specification 2 does a better job in explaining inflation behavior in Turkey than specification 1.

Following the evidence reported above, Figures 8 and 9 plot the actual inflation series together with the fundamental inflation series based on specification 2 only for CEM and OEM1, respectively.

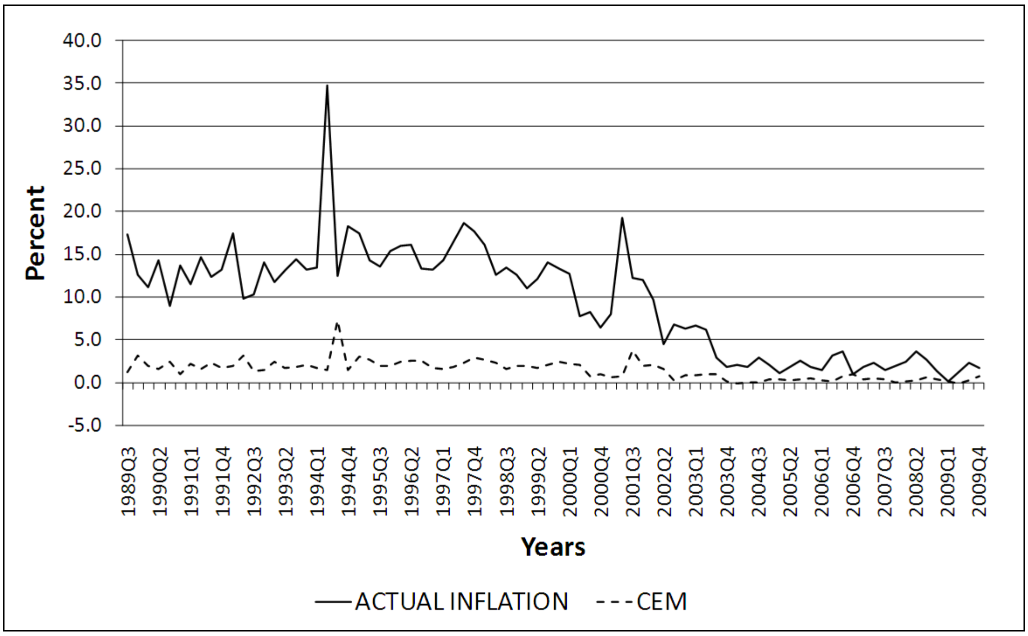

Figure 8 Fundamental Inflation Series for CEM and Actual Inflation

Source: Author's own calculations

Figure 8 shows that the closed economy model (CEM) with only labor employed as a factor of production, understates actual inflation behaviour uniformly across the entire estimation period for Turkey. Thus, a closed economy model that does not take the effect of the imported goods prices on inflation clearly cannot track the observed inflation dynamics in Turkey. Figure 9, on the other hand, indicates that the open economy model without imported intermediate goods (OEM1) seems to track the inflation behaviour in Turkey reasonably well. Although, simple visual inspection cannot reveal whether OEM1 or OEM2 is better, on basis of the measures of fit used, one can surely conclude that OEM2 outperforms OEM1, in terms of explaining actual inflationary developments in Turkey.

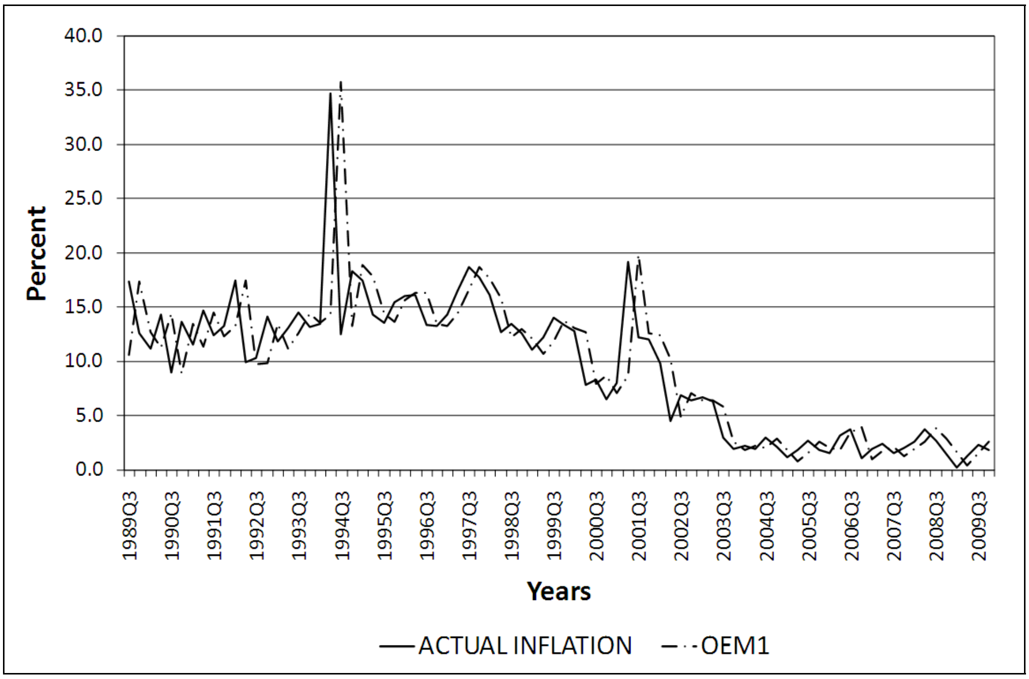

Figure 9 Fundamental Inflation Series for OEM1 and Actual Inflation

Source: Author's own calculations

IV.B.5.3 Comparison of parameters across models

Having shown that specification 2 outperforms specification 1 for all three models, in this subsection the comparison across structural parameters θ and ω and reduced form parameters γ_f and γ_b will be carried out using the estimates obtained for specification 2 in Table 4.

To investigate whether the structural form parameters θ and ω and reduced form parameters γ_f and γ_b are *statistically* different among the three models, following Rumler (2007), a *t-test* is carried out for the statistical significance of the difference between the coefficient estimates of the models. The results are summarized in Table 6 which reports the difference in the estimates of θ, ω, γ_f and γ_b between all pairs of models and the percentage difference in the parenthesis.

Table 6 t-tests for the difference between structural and reduced form parameter estimates in CEM, OEM1 and OEM2.

	θ	ω	γ_f	γ_b
CEM-OEM1	0.432	-0.488	0.405	0.412
(% difference)	(100.3)	(-67.8)	(107.7)	(66)
t-value	3.562	-4.552	4.086	4.124
CEM-OEM2	0.230	-0.503	0.321	0.327
(% difference)	(36.4)	(-68.4)	(69.8)	(60.6)
t-value	2.391	-4.701	3.830	3.844
OEM1-OEM2	-0.202	-0.014	0.084	0.086
(%difference)	(-31.9)	(-1.9)	(18.2))	(15.9)
t-value	-1.341	-0.838	1.139	1.165

Source: Author's own calculations

The estimated degree of price rigidity (θ) appears to be highest in the closed economy model CEM, with prices on average fixed for *22 months* (Table 4). Open economy model with labor, domestically produced and imported intermediate inputs, OEM2, and the open economy model with only domestically produced intermediate inputs, OEM1, follow CEM with reported average price durations close to each other; calculated equal to *8 and 5 months*, respectively (Tables 1 and 4).

The estimated degree of price rigidity falls *significantly* when moving from the CEM to OEM1, (Table 6). This can be attributed to the fact that domestic and local importer firms, whose costs vary more with changes in price imported final goods and domestically produced intermediate inputs, adjust their output prices more often than other firms in the closed economy whose only source of cost and thus price variation comes from change in labor prices. The same line of reasoning continues when CEM and OEM2 are compared with the added affect of imported intermediate input prices on costs of domestic firms and thereby their output prices. Since price of imported inputs like oil change frequently, this reveals itself as a statistically significant reduction in again the estimated degree of price rigidity in case of OEM2 when compared to CEM (Table 6).

When the estimates of degree of price rigidity between OEM2 and OEM1 are compared, one can see that the reported estimate increases when moving from OEM1 to OEM2. A similar result is reported in Rumler (2007) for the euro area countries. Rumler attributes this increase to the availability of substitution possibilities between imported and domestically produced intermediate inputs, thereby reducing the need to change prices often when price of imported intermediate inputs change. However, as discussed in Chapter II, since this substitution possibility is limited in Turkey the difference between the estimates of θ in OEM2 and OEM1 is not found statistically significant (Table 6).

In case of the structural parameter ω, which measures the degree of backwardness in price setting (and indicates the degree of intrinsic inflation inertia), we detect a reverse situation with the difference in the parameter estimates found *significantly* higher when moving from CEM to OEM1 or OEM2. Thus, the estimated degree of backwardness decreases *significantly* as the economy becomes a closed economy (Table 6). While in case of CEM 23 percent of all firms are found to follow the backward looking rule of thumb when setting their prices, this number has increased more than its triple in case of OEM2 and OEM1. Following Leith and Malley (2007), this can be attributed to the fact that the less frequently are firms able to change their prices (the high is θ) the less will be the fraction following the backward looking price (the low is ω) as costs involved with backward looking pricing increase when prices once set stay in existence for a much longer period of time.

Finally, let us compare the estimates obtained for the forward (γ_f) and backward looking components (γ_b) of inflation. Tables 4 and 6 indicate that inflation becomes predominantly forward looking as one moves from the open economy specifications to the closed economy specification. While the estimate of γ_f increases significantly as we go from OEM2 or OEM1 to CEM, the estimate of γ_b decreases (Table 6). This result can be explained with the increase in the degree of price rigidity and the decrease in the degree of inertia reported above when moving from the closed economy model to the open economy models. This finding explains clearly why Yazgan and Yilmazkuday (2005) which employ a closed economy specification end up with finding forward looking behaviour more important than backward looking behaviour[97]. This finding is also important in the sense that it also questions the validity of the findings reported for other countries that use closed economy models to explain inflation dynamics in fairly open economies like Mexico. Thus, in those studies, finding inflation predominantly forward looking may just stem from incorrect modeling of the economy in question as a closed economy.

When the estimates of γ_f and γ_b are compared for the two open economy specifications, one can see that neither change is found statistically significant. Thus, we can conclude that the estimates of OEM1 are not biased up or down in spite of OEM1 neglecting imported intermediate inputs in production whose incorporation increases the model's ability to explain observed inflation dynamics.

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[97] The estimates reported for γ_f and γ_b equal to 0.86 and 0.11 in Yazgan and Yilmazkuday (2005), which are quite comparable to our estimates reported for CEM in Table 4. The differences in estimates could be attributed to the different assumptions relating to the production technology.

IV.B.6 Continuous Updating GMM (CU-GMM) and Iterated GMM Estimation

In subsection IV.B.3 we reported the *two step GMM* estimators for our open economy hybrid NKPC model. The two step estimator obtained by minimizing equation (4.3) is both consistent and asymptotically efficient. However, the estimator used in the first step, $\hat{\theta}_T(1)$, is obtained using a sub-optimal choice of weighting matrix. Thus, better small sample gains are expected with using the two step estimator $\hat{\theta}_T(2)$ to construct a new estimate of *S*, $\hat{S}_T(2)$, and then re-estimating the parameters with $\hat{S}_T(2)^{-1}$. The estimator obtained, $\hat{\theta}_T(3)$, has the same asymptotic distribution as the two step estimator, but is anticipated to be more efficient in small samples. This potential small sample gain suggests continuing this process until the estimates converges, thereby obtaining the so called *iterated GMM* estimator. In case of iterated GMM estimator the GMM objective function takes the following form at the i^{th} stage:

$$Q_{iter,T}(\theta) = g_T(\theta)'\hat{S}_T(i-1)^{-1}g_T(\theta) \tag{4.33}$$

However, if one recognizes that *S* is also a function of θ in the objective function given above, then an alternative estimator can be obtained by defining the GMM objective function as follows

$$Q_{CUE,T}(\theta) = g_T(\theta)'S_T(\theta)^{-1}g_T(\theta) \tag{4.34}$$

The estimator obtained by minimizing over θ in equation (4.34) is known as the *continuous updating GMM* (CU-GMM) estimator introduced by Hansen, Heaton and Yaron (1996). When the GMM objective function is minimized over θ, in equations (4.3) and (4.33), the weighting matrix is taken as given. However, in case of the CU-GMM estimator, the derivative of the weighting matrix with respect to θ is also taken. The CU-GMM estimator has *three* very important advantages over the iterated and two step GMM estimators. First, it is invariant to the normalization of the moment conditions (Hansen, Heaton and Yaron, 1996; Hall, 2005). Second, CU-GMM estimator is partially robust to weak instruments in the nonlinear models (Stock et al., 2002). Third, CU-GMM estimator has better finite sample properties than the two step GMM estimator in Monte Carlo simulations (Guay and Pelgrin, 2004).

In light of the above discussion, to investigate the robustness of our results reported in Table 1 we have also reported the iterated GMM and CU-GMM estimation results for the structural parameters *θ, β, ω, ρ* and *γ* in Table (7) together with the implied estimates of the reduced form parameters $\gamma_f, \gamma_b, \lambda_{mc}$ and $\lambda_{loopgap}$. The instrument set used in both estimations is the same as the one used in case of the two step estimator. It includes a constant term and four lags of domestic price inflation, growth rate of USD-TL exchange rate, ratio of wages to import prices (i.e., $w_t - p_{F,t}$) and ratio of wages to domestic prices (i.e., $w_t - p_{H,t}$). The last two rows give the average duration of prices measured in months (denoted with D) and *p-value* of Hansen's test of overidentifying restrictions (J-test). All our estimations are carried out in MATLAB 7.0.4.

To our knowledge, there are only two studies that apply the CU-GMM estimator in a NKPC context (Guay and Pelgrin, 2004 and Kleibergen and Mavroeidis, 2009). Thus, in this respect, our approach again clearly distinguishes from any NKPC study applied to Turkish data.

When Table 7 is analyzed one can immediately note that all structural and reduced form parameters are statistically significant at 1 percent level and the open economy hybrid NKPC model is not rejected according to the Hansen's J-test. Therefore, the iterated GMM and CU-GMM estimators provides results that are consistent with those obtained from the two-step GMM estimation of the model (Table 1). The results based on both the iterated GMM and CU-GMM estimators show that the open economy NKPC developed for Turkey is empirically relevant and that inflation dynamics in Turkey may be accounted well by the NKPC.

Table 7 CU-GMM and Iterated GMM estimation results for the open economy hybrid NKPC model

Estimates of Structural Parameters[a]			
	Iterated GMM		CU-GMM
	Specification 1	Specification 2	
θ	0.650*** (0.004)	0.630*** (0.006)	0.626*** (0.006)
β	0.990*** (0.002)	0.990*** (0.002)	1.046*** (0.002)
ω	0.731*** (0.006)	0.731*** (0.008)	0.733*** (0.009)
ρ	-6.201*** (1.846)	-6.202*** (0.735)	-6.200*** (0.893)
γ	0.821*** (0.057)	0.590*** (0.040)	0.595*** (0.039)
D	8.6	8.1	7.8
J	0.996	0.996	0.996
Estimates of Reduced Form Parameters[b]			
γ_f	0.468*** (0.008)	0.460*** (0.010)	0.474*** (0.018)
γ_b	0.531*** (0.005)	0.539*** (0.011)	0.531*** (0.011)
λ_{mc}	0.002*** (0.001)	0.006*** (0.001)	0.006*** (0.001)
$\lambda_{loopgap}$	0.020*** (0.002)	0.016*** (0.001)	0.015*** (0.001)

Notes:
[a] The first part of this table presents the two-step GMM estimates of the structural form coefficients where the nonlinear two stage least squares estimator provides the initial consistent estimator.
[b] The second part of this table presents the implied estimates of the reduced form parameters calculated from equation (3.140) and their calculated standard errors. The standard errors of the reduced form parameters are computed according to Kmenta (1986).
[c] The figures in parentheses are standard errors.
[d]Asterisks (***,**,*) denote statistical significance at 1% , 5% and 10% levels, respectively.
Source: Author's own calculations

Moreover a comparison with two step standard errors reported in Table 1 indicates that iteration, in general, has increased the precision. In fact, with iteration all the reduced form parameters are more precisely estimated. However, the two step standard errors of the estimate of discount factor, β, in both specifications and the estimate of the constant elasticity of substitution between labor, imported and domestically produced intermediate inputs, ρ, in specification 1 have increased with iteration. Notwithstanding these differences, the two step estimation results are almost the same as those reported for the iterated estimator.

When the two step GMM estimates reported for specifications 1 and 2 in Table 1 are compared, the estimate of the degree of openness (γ) and the implied estimates of the coefficient on marginal cost and LOOP gap seem to depend on the normalization more than the estimates of the other structural and reduced form parameters. The same result continues also in case of the iterated GMM estimation results reported for specifications 1 and 2 in Table 7. With iteration, the percentage differences between the estimates obtained under specifications 1 and 2 have diminished considerably for the other structural parameters and the reduced form parameters. The CU-GMM, which is invariant to the normalization, allows us to solve between these conflicting results involving the normalization used. The estimates obtained with the CU-GMM estimator, which are robust to normalization, are closer to those obtained with the two step GMM and iterated GMM estimators for the second specification. This corroborates our earlier finding that specification 2 outperforms specification 1 when fundamental inflation series obtained under each case are compared with actual inflation.

IV.B.7 Estimates from the Closed Form Solution

In subsection IV.B.3 we have showed that the estimates of the structural and reduced form parameters obtained from the hybrid open economy NKPC specification derived for the Turkish economy are in the theoretically plausible range and statistically significant. Moreover, subsections IV.B.4 and IV.B.5 have indicated that the NKPC worked quite well in explaining the observed inflation behaviour in Turkey and it suited the Turkish economy better than a closed or open economy alternative. In this subsection we will demonstrate that our results are also robust to the direct estimation of the *closed form solution* given in equation (4.29).

Rudd and Whelan (2005a, 2006) have estimated the closed form solution of the hybrid NKPC equation developed in Galí and Gertler (1999), instead of its structural form, to circumvent any misspecification problem associated with estimating the structural form with GMM. They argue that the findings of Galí and Gertler (1999) and Galí et al. (2001) are misspecified because once the closed form solution is estimated directly the quantitative importance of the forward looking behaviour no longer continues to exist. However, Galí et al. (2005) have confirmed that their estimates obtained from the closed form solution coincide with those obtained from the structural form once the nonlinear relationships between the structural and reduced form parameters are taken into account.

Recall from subsection IV.B.4 that equation (4.29) was derived as the stable closed form solution of the second order NKPC difference equation and called as fundamental inflation when expected terms were forecasted with a vector autoregressive (VAR) process. Here we follow Rudd and Whelan (2005a) and estimate this equation directly using GMM after the infinite discounted sum of expected future values of the real marginal cost and the LOOP gap appearing in equation (4.29) are made empirically operable by using a truncated sum as follows:

$$\pi_t = \varsigma\pi_{t-1} + \varphi_1 \sum_{i=0}^{k} \eta^i E_t mc_{t+i} + \varphi_2 \sum_{i=0}^{k} \eta^i E_t \psi_{F,t+i} + \eta^{k+1}(E_t mc_{t+k+1} + E_t \psi_{F,t+k+1} - \varsigma\pi_{t+k}) \tag{4.35}$$

where

$$\varsigma = \delta_1,\ \varphi_1 = \lambda_{mc}/(\delta_2\gamma_f),\ \varphi_2 = \lambda_{loopgap}/(\delta_2\gamma_f),\ \eta = 1/\delta_2 \qquad (4.36)$$

We estimate equations (4.35) - (4.36) using GMM noting that the future value of a variable is equal to its (rational) expectation at time *t* plus an expectational error. The instrument set used includes a constant term and four lags of consumer price inflation, growth rate of USD-TL exchange rate, marginal cost and LOOP gap. Table 8 reports the coefficients ς, φ_1, φ_2 and η obtained from estimating the closed form solution and the implied reduced form parameters γ_f, γ_b, λ_{mc} and $\lambda_{loopgap}$ obtained by solving the equations given in (4.29). For the results given in Table 8, *k* is taken as 16 quarters, but the results are robust for values of k varying from 8 to 24 quarters. The standard errors of the parameter estimates are given in parentheses. The last two rows give the *p-value* of Hansen's test of overidentifying restrictions (J-test) and the Geary Sign – Change test (GS-test) (Geary, 1970) conducted on the residuals of the closed form solution.

Table 8 indicates that all the coefficient estimates of the closed form solution are statistically significant at 1 percent significance level. Moreover, the J-test statistic does not reject the null hypothesis that the overidentifying moment conditions are valid and supported by the data. GS-test shows no serial correlation problem in the residuals of the closed form solution and thus the lags of the dependent variables can be used comfortably as instruments[98]. Overall the estimates of the reduced form parameters reported in Table 8 are consistent with those given in Table 1. The reduced form coefficients are positive and statistically significant at the 1 percent significance level and very similar to those obtained from estimating the structural form. Thus, we can conclude once more that both backward and forward looking behaviour are quantitatively important in Turkey. Although the coefficients of the two are

[98] See footnote 95.

estimated close to each other, inflation is still characterized with predominantly backward looking behaviour.

Table 8 Estimates obtained from the closed form solution

Closed Form Coefficients[a]			
ζ	φ_1	φ_2	η
0.999***	0.126***	0.736***	0.771***
(0.018)	(0.038)	(0.007)	(0.065)
J-test	0.9871		
GS-test	0.1032		
Reduced form Coefficients[b]			
γ_f	γ_b	λ_{mc}	λ_{mc}
0.435***	0.565***	0.007***	0.042***
(0.0791)	(0.0311)	(0.0025)	(0.0028)

Notes:
[a] The first row of this table reports the two-step GMM estimates of the closed form coefficients given in equation (4.35).
[b]The reduced form parameters are recovered from equation (4.36) and their calculated standard are computed according to Kmenta (1986).
[c] The figures in parentheses are standard errors.
[d] Asterisks (** ,*,**,*) denote statistical significance at 1% , 5% and 10% levels, respectively.
Source: Author's own calculations

IV.B.8 Structural Stability Analysis

The purpose of this subsection is to investigate the possibility of structural changes in the open economy hybrid NKPC model over time. Econometric structural stability analysis of the NKPC has been rather limited within the context of the Turkish economy[99]. However, over the long period of the post-

[99] Çatik et al. (2008), Celasun (2006), Yazgan and Yilmazkuday (2005) and Celasun et al. (2004a) have estimated NKPC equations for the Turkish economy, but did not conduct any

1980s, both economic structure and monetary policy in Turkey have experienced considerable changes that may have had sufficient impact on the behavior of economic agents to cause instability in the NKPC model. Therefore, before performing the structural break point tests we will first briefly summarize the key developments that took place in Turkey over the post 1980 period.

IV.B.8.1 The Turkish Economy in the post 1980 period

In 1980, Turkey started to liberalize its internal financial system and introduced measures to deregulate the interest rates in the banking sector[100]. In May 1981, the Central Bank of Turkey adopted the *crawling peg exchange rate regime* in which exchange rates were adjusted on a daily basis (Özatay, 2000). Until this date Turkey was following a fixed exchange rate regime.

After 1989, Turkey adopted policies to liberalize its external financial system (Kepenek and Yentürk; 2010, p. 213). These policies, one the one hand, liberated the capital movements and, one the other hand, allowed the Turkish residents to conduct their economic transactions using foreign exchange. The final important step towards the liberalization of foreign exchange regime was taken on 11 August 1989 with the adoption of the Decree No. 32 on Protection of Turkish Currency by the Turkish Council of Ministers (Kepenek and Yentürk; 2010, pp 321-322). This decree together with other decrees passed in 1983 and 1884 and various Communiqués of the Central Bank of Turkey set out the fundamental principles on the domestic and international exchange of

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stability analysis. The only notable exceptions are the studies of Agénor and Bayraktar (2010) and Celasun et al. (2004b). Agénor and Bayraktar (2010) analyze the structural stability of only the reduced form parameters of the NKPC by conducting structural stability tests. Their results have revealed 1994Q1 as the break point for Turkey. On the other hand, Celasun et al. (2004b), without performing structural stability tests, have included a dummy variable to account for the 1994 crisis. To our knowledge there is no study that analyzes the possibility of structural instability in the structural parameters of the NKPC for the Turkish economy.

[100] Before 1980s Turkey was characterized by many different restrictions on crucial aspects of the economy like constraints on capital movements, financial markets, foreign exchange regime. See Kepenek and Yentürk (2010) for a detailed discussion.

currencies, precious metals, goods and capital in Turkey[101]. In February 1990, Turkey applied to the IMF for the *full convertibility* of the Turkish lira.

In 1994 Turkey experienced a severe financial crisis that erupted at the beginning of 1994 and ended at the end of May, when Treasury was able to borrow again from the domestic debt market after the standby by agreement signed with the International Monetary Fund (IMF) (Özatay, 2000). As a result, during the first quarter of 1994, TL depreciated by almost 70 percent against the U.S. dollar and the overnight interest rates jumped to 700 percent from a stable pre-crisis level of around 70 percent. Besides, Turkey contracted by 6 percent in 1994.

Four years after the 1994 crisis, Turkey was this time hit by the 1998-1999 Russian crisis. However, the Russian crisis did not affect the exchange rate, the overnight interest rates or the market pressure index as badly as did the 1994 crisis or the 2000-01 crisis discussed below[102]. Turkey continued to grow at a rate of 3.1 percent at 1998 but contracted by 4.7 percent in 1999 (which is nearly half of the negative rate experienced in 2001) (Özatay, 2010, p. 135).

In December 1999, Turkey, which was following a *managed floating* exchange rate regime, started to implement an exchange rate based disinflation program supported by the IMF and adopted a *pre-announced crawling peg* exchange rate regime. Thus, Turkey, which was following a flexible exchange rate policy until January 2000, started to implement a fixed exchange rate policy after the introduction of this new disinflation program[103,104]. However during the

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[101] Kepenek and Yentürk (2010, p. 322) argue that with the adoption of Decree No. 32, Turkey *implicitly* accepted the *full convertibility* of the Turkish lira.

[102] Özatay and Sak (2002) have used a *market pressure index* to identify the 1994 and 2000-01 crises. This index was calculated as a weighted average of monthly rates of changes of exchange rate, official reserves and overnight interest rates where inverse of each variables' variance was used as weights.

[103] As argued in Özatay (2000), as of the end of 1993, the IMF in its annual report on exchange rate arrangements and restrictions stated that Turkey followed a *flexible* exchange rate policy.

implementation of this program Turkey was hit by a second severe financial crisis starting in the second half of November 2000 and continuing to the first half of 2001. Due to this crisis, 4 months before Turkey would allow the exchange rate to fluctuate, the exchange rate system collapsed and on February, 22 2001 Turkey had to declare that it switched to a floating exchange rate regime. After this declaration, TL depreciated by 40 percent against the U.S. dollar in one day (Özatay and Sak, 2002). During this second crisis, the overnight interest rates skyrocketed to unprecedented levels of 6200 percent (on February 21, 2001) and in the November 2000 – March 2001 period the interest rates in the secondary hand Treasury bond market increased at a rate of 401.5 percent (Özatay, 2010, p. 139)[105]. Two months later, in April 25, 2001 the Central Bank law was changed and the bank obtained tool independence (Özatay, 2009). With this law, *achieving price stability* became the priority goal of the bank explicitly. The fluctuations in the markets continued until Turkey announced in May 2001 that it will implement a new IMF based program, namely the "Transition to the Strong Economy Program". Consistent with this program Turkey adopted first an *implicit inflation targeting regime* (IITR) in 2002 and then introduced the *inflation targeting regime* (ITR) formally in 2006, to cure its chronic and high inflation[106]. In 2001, Turkey experienced a sharp contraction of 8.5 percent which was far worse than that happened in 1994 or 1999.

Unfortunately, 6 years after the 2000-01 crisis Turkey was once more hit by a financial crisis that started in the second half of 2007 and deepened in 2008. The 2007 global financial crisis affected Turkey more severely than the 1998

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[104] Özatay (2009) has termed the preannounced crawling peg regime implemented by Turkey between January 2000 and February 2001 as a *fixed* exchange rate regime. The regime starting from the beginning of 2000 had declared what the exchange rate would be for a 1.5 year horizon and after that allowed the exchange rate to fluctuate in a continuously widening band.

[105] Özatay (2010, pp. 137-138) states that after 2002, the overnight interest rates were only allowed to fluctuate in a band and thus, to measure the market pressure in the post February 22 period uses the interest rates in the secondary hand Treasury bond market.

[106] The reasons behind why Turkey had to adopt first an implicit inflation targeting regime are discussed briefly in Kara (2008).

crisis and caused an unprecedented negative growth rate of 14.3 percent in the first quarter of 2008 (Özatay, 2010, p. 136).

After the 1994 and the 2000-01 crisis, the inflation behavior in Turkey experienced important changes. Figure 10 graphs the evolution of the CPI inflation rate and its volatility together with average inflation. As a result of the 1994 crisis, the annual inflation rate soared to an unprecedented level of 125 percent at the end of 1994. In addition, the volatility of inflation increased to 6 percent from a pre crisis level of about 1 percent[107]. After the crisis, in the 1995-1999 period, the annual inflation fluctuated below the 100 percent level around an average rate of 79 percent. The volatility of inflation also decreased to the pre crisis level of 1 percent during the 1995-1999 period.

At the end of 2001, the inflation rate which had decreased to 39 percent in 2000, reached once again to the 69 percent level. However, after four years of successful implementation of the *IITR* in the post 2001 period, inflation was decreased below 10 percent in 2005. In 2009, after four years of implementation of the *formal ITR*, inflation decreased to 7 percent, its lowest level in the last 20 years. Moreover, average inflation, which was about 74 percent in the period before the implementation of the *IITR*, fell to 16 percent in the period 2002-2009 (Figure 10). Not only did the average inflation decrease in this period, but also the volatility of inflation fell with the start of the *IITR* in 2002. Figure 10 shows a clear decline in inflation volatility after the 2002 period, from 1 percent in 1995-1999 period and 2 percent in the year 2001 to 0.7 percent during the *IITR* and 0.5 percent during the *ITR*.

[107] In plotting Figure 10, inflation volatility was calculated following the methodology used in Blanchard and Simon (2001)

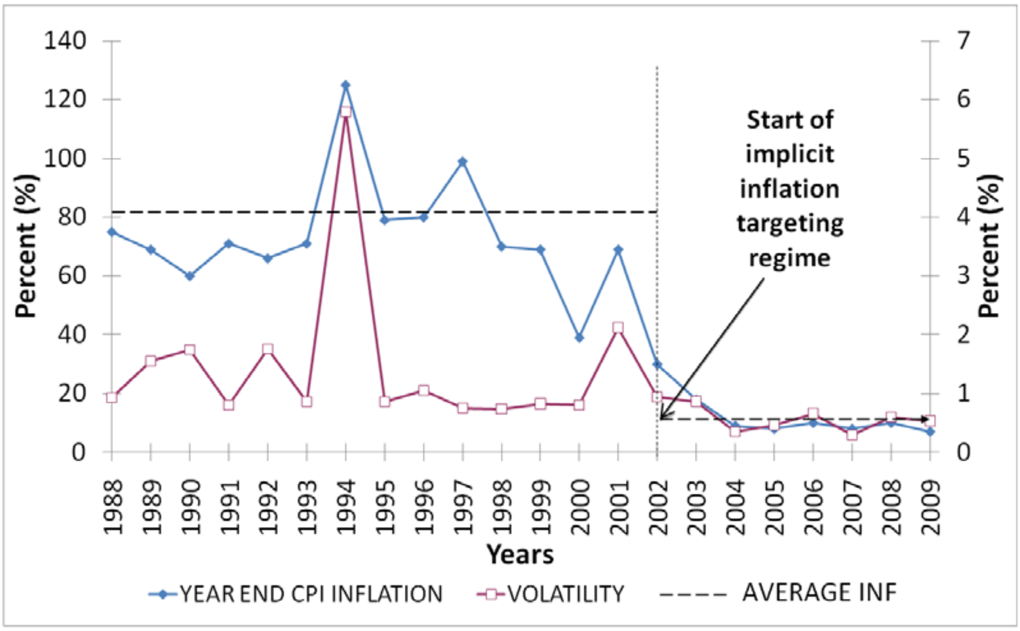

Figure 10 End-Year Annual CPI Inflation, Inflation Volatility and average inflation for the period 1988 -2009

Source: CBRT (2010a) and author's own calculations

Notice from Figure 10 that the 1998 Russian crisis or the more recent 2007 global financial crisis didn't have a noteworthy effect on the behavior of inflation and its volatility in Turkey. In other words, that there was neither a short run spike in inflation and inflation volatility as it happened in the case of the 1994 crisis nor a continual decrease in its level and volatility as experienced after the 2000-01 crisis.

To investigate whether any of the aforementioned developments were significant enough to induce structural instability in our open economy hybrid NKPC model, we have performed structural break point tests based on GMM estimators using the methodology developed by Andrews (1993), Andrews and Ploberger (1994), and Hall (2005, pp. 170-193). However, as argued in Hall (2005, pp. 170-193) the GMM literature has thus far concentrated on cases that allow only for a *single break point* in the sample. Multiple break tests have been developed by Bai (1997) and Bai and Perron (1998), but these could only be applied within the context of *linear* regression models. Before reporting and discussing the results of these tests, we will in the next subsection describe the methodology of structural break testing based on GMM estimators.

IV.B.8.2 Structural Stability Tests

The null hypothesis of structural stability in the context of GMM is formulated as follows[108];

$$H_0^{SS}(\pi): E\left[f(\upsilon_t, \theta_0)\right] = 0 \quad \text{for all } t \in T_1 \,\&\, T_2 \tag{4.37}$$

where θ_0 denotes the unknown $(p \times 1)$ parameter vector, υ_t is a $(q \times 1)$ vector of instruments, $E\left[f(\upsilon_t, \theta_0)\right]$ represents the population moment condition, π is a constant defined over the interval (0,1) with $\left[\pi T\right]$denoting the potential break point, $T_1 = \left\{1, 2, ...\left[\pi T\right]\right\}$ denotes the first subsample including observations before the break point and $T_2 = \left\{\left[\pi T\right] + 1, ...T\right\}$gives the second subsample including observations after the break point. As will be discussed below, the break point $\left[\pi T\right]$ will be treated as known or unknown in the construction of the structural stability tests.

Instead of working with $H_0^{SS}(\pi)$directly, Hall (2005) decomposes it into two hypotheses to consider the instability arising from the violation of the *identifying* and *overidentifying* restrictions separately.

The *identifying* restrictions are said to be structurally stable if they are satisfied by the same parameter value in each subsample. This null hypothesis is formally stated as

[108] This section based extensively on Hall (2005, pp. 170-193).

$$H_0^I(\pi): P_1\left(\theta_0,\pi\right)\left\{S_1\left(\theta_0,\pi\right)\right\}^{-1/2} E_1\left[f\left(\upsilon_t,\theta_0\right)\right]=0, \quad t\in T_1$$

$$P_2\left(\theta_0,\pi\right)\left\{S_2\left(\theta_0,\pi\right)\right\}^{-1/2} E_2\left[f\left(\upsilon_t,\theta_0\right)\right]=0, \ t\in T_2 \tag{4.38}$$

where $P_i\left(\theta,\pi\right)=F_i\left(\theta,\pi\right)\left[F_i\left(\theta,\pi\right)' F_i\left(\theta,\pi\right)\right]^{-1} F_i\left(\theta,\pi\right)'$ for the two subsamples represented by *i=1,2*, $F_i\left(\theta,\pi\right)=S_i\left(\theta,\pi\right)^{-1/2} E_i\left[\partial f\left(\upsilon_t,\theta_i\right)/\theta'\right]$ for *i=1,2*, $E_i\left[...\right]$ denote the expectation operator relative to the data generation process for υ_t in T_i and $S_i\left(\theta,\pi\right)$ denotes the variance covariance matrix of moment conditions in each subsample.

On the other hand, the *overidentifying* restrictions are said to be structurally stable if they hold both before and after the break point. This null hypothesis is formally states as

$$H_0^O\left(\pi\right)=H_0^{O1}\left(\pi\right)\&H_0^{O2}\left(\pi\right) \tag{4.39}$$

where

$$H_0^{O1}(\pi):\left[I_q-P_1\left(\theta_1,\pi\right)\right]\left\{S_1\left(\theta_1,\pi\right)\right\}^{-1/2} E_1\left[f\left(\upsilon_t,\theta_1\right)\right]=0, \qquad t\in T_1$$

$$H_0^{O2}(\pi):\left[I_q-P_2\left(\theta_2,\pi\right)\right]\left\{S_2\left(\theta_2,\pi\right)\right\}^{-1/2} E_2\left[f\left(\upsilon_t,\theta_2\right)\right]=0, \ t\in T_2$$

According to Hall (2005), distinguishing between these two possible sources of instability conveys the researcher valuable model building information. If $H_0^I(\pi)$ is violated while $H_0^O(\pi)$ is not, then the instability is said to be confined to the *parameters* alone. More specifically, in this case one can safely conclude that only the values of the parameters have changed but all the other aspects of the model have stayed the same. However, in the case that both $H_0^O(\pi)$ and $H_0^I(\pi)$ are violated, then this would signal model misspecification and lead to the conclusion that instability is *not confined* to the parameter vector alone but other aspects of the model are affected as well.

In the *known* break point case, Hall (2005) argues that to test $H_0^I(\pi)$ for models estimated by GMM, the literature has followed two approaches. Either Lagrange Multiplier (LM), Wald (W) or Likelihood Ratio (LR) type tests of parameter constancy proposed by Andrews and Fair (1988) are used or the Predictive test proposed by Ghysels and Hall (1990) is applied. However, since it is shown that the Predictive test has no power against the violations of $H_0^{O1}(\pi)$, Hall (2005) deems the use of this test to be less attractive than the combined use of Wald, LM or LR statistics and the $O_T(\pi)$ statistic described below. Therefore, following Hall (2005) we do not perform a Predictive test on the structural parameters of our open economy hybrid NKPC.

Within the context of the first approach, Andrews (1993) has proposed versions of the LM and D (or LR) tests that use the *full sample GMM estimator* in place of the *restricted* estimator. Thus, the LM statistic for testing the null hypothesis of $H_0^I(\pi)$ takes the form

$$LM_T(\pi) = \frac{T\pi}{(1-\pi)} g_{1,T}(\hat{\theta}_T;\pi)\hat{S}_T^{-1}G_T(\hat{\theta}_T)\left[G_T(\hat{\theta}_T)'\hat{S}_T^{-1}G_T(\hat{\theta}_T)\right]^{-1}$$

$$\times G_T(\hat{\theta}_T)'\hat{S}_T^{-1}g_{1,T}(\hat{\theta}_T;\pi) \qquad (4.40)$$

where $\hat{\theta}_T$ is the full sample GMM estimator, $\hat{S}_T$ is a consistent estimator of S (the variance-covariance matrix of moment conditions), $G_T(\theta) = T^{-1}\sum_{t=1}^{T}\left[\partial f\left(\upsilon_t,\theta\right)/\theta'\right]$ is the full sample derivative matrix and

$g_{1,T}\left(\theta;\pi\right)=\left[\pi T\right]^{-1}\sum_{t=1}^{[\pi T]}f\left(\upsilon_t,\theta\right)$ gives the sample moment in the first subsample T_1.

The Wald statistic is given by

$$W_T(\pi)=T\left[\hat{\theta}_{1,T}\left(\pi\right)-\hat{\theta}_{2,T}\left(\pi\right)\right]'\hat{V}_W\left(\pi\right)^{-1}\left[\hat{\theta}_{1,T}\left(\pi\right)-\hat{\theta}_{2,T}\left(\pi\right)\right] \tag{4.41}$$

where

$$\hat{V}_W\left(\pi\right)=\frac{1}{\pi}\left[G_{1,T}(\hat{\theta}_{1,T}\left(\pi\right);\pi)'\hat{S}_{1,T}\left(\pi\right)^{-1}G_{1,T}(\hat{\theta}_{1,T}\left(\pi\right);\pi)\right]^{-1}$$

$$+\frac{1}{1-\pi}\left[G_{2,T}(\hat{\theta}_{2,T}\left(\pi\right);\pi)'\hat{S}_{2,T}\left(\pi\right)^{-1}G_{2,T}(\hat{\theta}_{2,T}\left(\pi\right);\pi)\right]^{-1} \tag{4.42}$$

and

$\hat{\theta}_{i,T}\left(\pi\right)$ denotes the *unrestricted* subsample two step GMM estimators for *i =1,2,* $\hat{S}_{i,T}\left(\pi\right)$ denotes a consistent estimator of $S_i\left(\pi\right)$ based on the unrestricted estimator $\hat{\theta}_{i,T}\left(\pi\right)$ and $G_{i,T}\left(\theta;\pi\right)$ represents the subsample derivative matrices given by $G_{1,T}(\theta;\pi)=\left[\pi T\right]^{-1}\sum_{t=1}^{[\pi T]}\left[\partial f\left(\upsilon_t,\theta\right)/\theta'\right]$ for *i=1* and $G_{2,T}(\theta;\pi)=\left(T-\left[\pi T\right]\right)^{-1}\sum_{t=[\pi T]+1}^{T}\left[\partial f\left(\upsilon_t,\theta\right)/\theta'\right]$ for *i=2*.

The D statistic is given by

$$LD_T(\pi)=T\left[J\left(\hat{\theta}_T,\hat{\theta}_T;\pi\right)-J\left(\hat{\theta}_{1,T}\left(\pi\right),\hat{\theta}_{2,T}\left(\pi\right);\pi\right)\right] \tag{4.43}$$

where

$$J(\theta_1,\theta_2;\pi) = \pi g_{1,T}(\theta_1;\pi)' \widehat{S}_{1,T}(\pi)^{-1} g_{1,T}(\theta_1;\pi)$$

$$+(1-\pi) g_{2,T}(\theta_2;\pi)' \widehat{S}_{2,T}(\pi)^{-1} g_{2,T}(\theta_2;\pi) \quad (4.44)$$

and $g_{2,T}(\theta;\pi) = (T-[\pi T])^{-1} \sum_{t=[\pi T]+1}^{T} f(\upsilon_t,\theta)$ denotes the sample moment in the second subsample T_2.

Andrews and Fair (1988) have shown that all the above statistics converge in probability to χ_p^2. Since the calculation of both the Wald and LR statistics are based on the unrestricted subsample two step GMM estimators $\widehat{\theta}_{i,T}(\pi)$, to avoid the small sample problem that may affect the estimation results when the subsamples are estimated separately, for the present case we will use the LM statistic that requires only $\widehat{\theta}_T(\pi)$ in its construction.

To test $H_0^O(\pi)$ in the context of the *known* break point case, Hall and Sen (1999) have proposed the statistic $O_T(\pi) = O_{1,T}(\pi) + O_{2,T}(\pi)$ where $O_{1,T}(\pi)$ and $O_{2,T}(\pi)$ are the overidentifying restrictions test statistics (Hansen's J test) based on the subsamples T_1 and T_2, respectively. Hall and Sen (1999) have shown that $O_T(\pi) \xrightarrow{p} \chi^2_{2(q-p)}$, and $O_{1,T}(\pi)$ and $O_{2,T}(\pi)$ are $\xrightarrow{p} \chi^2_{(q-p)}$.

For the *unknown* break point case, Hall (2005) argues that although one may want to test for instability at any point in the sample, for practical purposes focus has to be limited to the null hypothesis:

$$H_0^{SS}(\Pi) = H_0^{SS}(\pi), \text{ for all } \pi \in \Pi \subset (0,1) \quad (4.45)$$

where $\Pi = [\pi_L, \pi_U]$ and π_L and π_U are the lower and upper endpoints of the interval Π. While Π should be wide for the null hypothesis to treat as many points as possible from the whole sample as potential break points, it should not be so wide that asymptotic theory is a poor approximation in the subsamples[109]. Likewise the known break point case, the null hypothesis is decomposed into two components that test for the stability of the identifying and overidentifying restrictions as follows

$$H_0^{SS}\left(\Pi\right) = H_0^{I}\left(\Pi\right) \,\&\, H_0^{O}\left(\Pi\right) \tag{4.46}$$

where

$$H_0^{I}\left(\Pi\right) = H_0^{I}\left(\pi\right), \quad \text{for all } \pi \in \Pi \subset \left(0,1\right) \tag{4.47}$$

$$H_0^{O}\left(\Pi\right) = H_0^{O}\left(\pi\right), \quad \text{for all } \pi \in \Pi \subset \left(0,1\right) \tag{4.48}$$

As argued in Hall (2005), to test $H_0^{I}\left(\Pi\right)$ again LM, Wald or D statistics are used, but in this case these statistics are calculated for each possible π and a sequence of statistics indexed by π is obtained[110]. Then, inference is done using the following three statistics that are based on different functions of this sequence:

$$SupLM = \sup_{i \in T_b} \left\{ LM(i/T) \right\} \tag{4.49}$$

$$AvLM = d(\pi_L, \pi_U, T)^{-1} \sum_{i=[\pi_L T]}^{[\pi_U T]} LM(i/T) \tag{4.50}$$

[109] Andrews (1993) have showed that the limiting distributions of SupLM, SupW or SupD diverge to infinity in probability for $\Pi = \left[0,1\right]$.

[110] Ghysels, Guay and Hall (1998) have also extended the Predictive test to the unknown break point case but for the same reason discussed above we have refrained from applying this test.

$$ExpLM = \log\left\{ d(\pi_L, \pi_U, T)^{-1} \sum_{i=[\pi_L T]}^{[\pi_U T]} \exp\left[0.5LM(i/T)\right] \right\} \tag{4.51}$$

where T_b denotes the set of possible break points given by $T_b = \{i/T; i = [\pi_L T], [\pi_L T]+1, ..., [\pi_U T]\}$ and $d(\pi_L, \pi_U, T) = [\pi_U T] - [\pi_L T] + 1$[111]. Hall (2005) states that these functions are chosen so as to maximize power against a local alternative in which a weighting distribution is used to indicate the relative importance of departures from $H_0^I(\Pi)$ in different directions at different break points.

Using the same line of reasoning, Hall and Sen (1999) have proposed the following statistics to test the null hypothesis that $H_0^O(\pi)$ holds for all $\pi \in \Pi = [\pi_L, \pi_U]$:

$$SupO_T = \sup_{i \in T_b} \{O_T(i/T)\} \tag{4.52}$$

$$AvO_T = d(\pi_L, \pi_U, T)^{-1} \sum_{i=[\pi_L T]}^{[\pi_U T]} O_T(i/T) \tag{4.53}$$

$$ExpO_T = \log\left\{ d(\pi_L, \pi_U, T)^{-1} \sum_{i=[\pi_L T]}^{[\pi_U T]} \exp\left[0.5O_T(i/T)\right] \right\} \tag{4.54}$$

IV.B.8.3 Structural Stability Test Results

We have performed both known and unknown break point tests on the structural parameters of our hybrid open economy NKPC. Known break point

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[111] For brevity, we have stated the statistics in terms of the LM statistic but all three of these statistics can be equally constructed for either the Wald or the LR statistic.

tests were conducted to test whether the 1994 and 2001 crises discussed above had sufficient impact on the behavior of economic agents to cause instability in the NKPC model[112]. Unknown break point tests were performed, on the one hand, to corroborate the evidence found from the known break point tests and, on the other hand, to consider other break points whose timing might not exactly be known but may result from any of the other events discussed in the first subsection.

Table 9 summarizes the results of the *known* break point tests performed on the open economy hybrid NKPC estimated in subsection VI.B.3. All estimations were carried out in MATLAB 7.0.4. We have performed structural stability tests taking 1994Q1, 1994Q2, 2000Q4, 2001Q1 and 2001Q2 as the potential break points. To cover the whole crisis period (i.e. the time through which it started and ended), we have conducted the test for the 1994 crisis on both the first and the second quarter of 1994 and the test for the 2000-01 crisis on the last quarter of 2000 and the first and second quarter of 2001[113]. The values in parentheses denote the *p-values* associated with the LM test statistic for the null hypothesis of no structural change.

Table 9 reveals that for all the break points considered, the overidentifying restrictions based tests were found insignificant at the conventional significance levels. However, the LM based identifying restrictions test, except for 2000Q4, is found significant at the conventional significance levels. This indicates that for all break points considered here, except 2000Q4, instability is confined to the parameters alone and does not affect our model's specification. Therefore, instability found in this present case does not cause a more fundamental misspecification involving more than just the parameters. While

[112] We limit our attention to the 1994 and 2001 crises because as argued before neither the 1998 nor the 2007 crisis has caused a significant change in the inflation dynamics in the period considered in this study.

[113] Özatay and Sak (2002) also using a pressure index to identify the 1994 and 2000-01 crises have showed that at two instances this index exceeded its mean plus two standard deviations: in the February to April 1994 period and the February to April 2001 period.

the model specification is correct before and after the break points, the structural parameters seem to have endured the changes.

Table 9 Known Break Point Structural Stability Tests

	1994Q1	**1994Q2**	**2000Q4**	**2001Q1**	**2001Q2**
LM	256.66 (0.00000)	211.43 (0.00000)	2.5871 (0.76333)	34.262 (0.00000)	28.708 (0.00003)
$\mathbf{O_T}$	9.7007 (0.98882)	9.4049 (0.99095)	10.18 (0.9846)	10.145 (0.98494)	10.232 (0.98408)
$\mathbf{O_{1T}}$	3.0904 (0.98948)	3.1812 (0.98811)	5.5904 (0.89925)	5.6786 (0.89393)	5.857 (0.88273)
$\mathbf{O_{2T}}$	6.6102 (0.82971)	6.2236 (0.85803)	4.5895 (0.94941)	4.4664 (0.95424)	4.3751 (0.95763)

Source: Author's own calculations

At 2000Q4 both the overidentifying and identifying restrictions based tests indicate that there is no structural instability. During this first period of the 2000-01 crisis, the government presented a new letter of intent to the IMF which helped to calm down the turbulence in the markets (Özatay and Sak, 2002). Also the central bank was successful in defending the first attack against lira which occurred during this period. Thus, the results of the stability tests seem to corroborate the evidence that the above mentioned events were able to calm down the turmoil in the markets during the first period of the crisis.

Table 10 reports the structural stability tests when the break point is treated as *unknown*. The first and second rows give the LM and O based *Sup*, *Av* and *Exp* tests defined in equations (4.49) – (4.54) for the null hypothesis of no structural change. The column labeled date reports the estimated break date corresponding to the *Supremum* statistic.

Table 10 Unknown Break Point Structural Stability Tests

	Sup-	Date	Av-	Exp-
LM	256.66***	1994Q1	20.163***	124.42***
O	10.269	1995Q2	9.741	4.887

Notes:
[a] Asterisks (***,**,*) denote statistical significance at 1% , 5% and 10% levels, respectively.
[b] The 10%, 5% and 1% critical values are 15.63, 17.88 and 21.90 for SupLM; 7.97, 9.23 and 11.71 for AvLM; and 5.16, 6.06 and 7.85 for ExpLM. These values are taken from Andrews and Ploberger (1994) [Tables 1 and 2] and Andrews (2003) [Table 1] for p=5 (the number of parameters estimated) and π_0=0.20 (equal to π_0 in terms of our notation).
[c] The 10%, 5% and 1% critical values are 31.61, 16.65 and 21.12 for SupO; 22.44, 24.78 and 29.52 for AvO; and 12.79, 14.12 and 16.8 for ExpO. These values are taken from Hall and Sen (1999) [Table 1] and represent the critical values for Π = [0.15, 0.85] and q-p=8 (the degree of overidentification). In our case q-p =12 but the critical values derived by Hall and Sen (1999) strictly increase with (q-p). Therefore, since in all cases the calculated statistics are insignificant at all significance levels for q-p=8, they would continue to be insignificant at q-p=12.
Source: Author's own calculations

As it can be seen from the results in Table 10, the identifying restrictions based break test statistics testing parameter variability are highly significant, with all the three statistics providing similar results. On the other hand, the overidentifying restrictions based tests were all found insignificant at the conventional levels. Thus, the instability found is subject to the structural parameters alone and does not affect our models misspecification. So far, all the evidence presented is consistent with our earlier findings based on known break point tests given in Table 9.

Furthermore, the break date estimates corresponding to the *SupLM* test occur at 1994Q1. Thus, the unknown break point test picks up the 1994 crisis as source of instability, but why not the 2000-01 crisis? As argued in Hall (2005, p. 185) this could reflect the fact that small sample size at either end of the interval Π may limit the applicability of asymptotic theory on which these tests rely on. As a result of this the supremum may occur close to $\pi_L = 0.20$ and $\pi_U = 0.80$, because the sequence of test statistics has not converged in distribution over the entire interval Π. In our case the interval $\Pi = [0.20, 0.80]$ corresponds to [1993Q1, 2005Q2] and the supremum seems to have occurred very close to the start date of 1993Q1.

In light of the results given above, dummy variables that account for the 1994 and 2000-01 crises were defined to investigate the nature of the structural breaks, i.e. which structural parameter changes before and after the breaks. Inspection of Figure 11 and the discussion made therein made it clear that the 1994 crises caused a *one time* jump in the level of inflation rate, while the policy change introduced after the 2000-01 crisis caused a *permanen*t change in not only the level of the inflation but also the average inflation and volatility of the inflation in the period up to 2009. Therefore, to reflect these changes, the dummy variable that represented the 1994 crisis was set to 1 at 1994Q1 and 1994Q2 and zero otherwise. On the other hand, a level dummy variable was defined to account for the 2000-01 crisis so that it was set to zero before 2001Q1 and unity otherwise. However, as a result of the GMM estimation performed on the whole sample, the coefficients of all the dummy variables were found insignificant. Thus the results did not provide any evidence on which coefficients change, presumably due to the relatively short subsamples available in the post-1994 and 2001 periods and the associated collinearity induced by the multiplicative dummy variables[114].

Although the dummy variable analysis did not allow us to arrive at a clear conclusion on the nature of changes in the structural coefficients, we will try to do so in the next subsection by conducting a subsample analysis. As argued above, the 1994 crisis only induced a one time jump in the level of inflation in the crisis year. In the post crisis period, no real change was introduced in the conduct of monetary or fiscal policy and therefore inflation, although fluctuating at a relatively lower average level when compared to 1994,

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[114] Celasun et al. (2004b) have also included a dummy variable to account for the 1994 crisis, but since its estimated coefficient is not presented among the estimation results one can deduce nothing about the statistical significance of its coefficient.

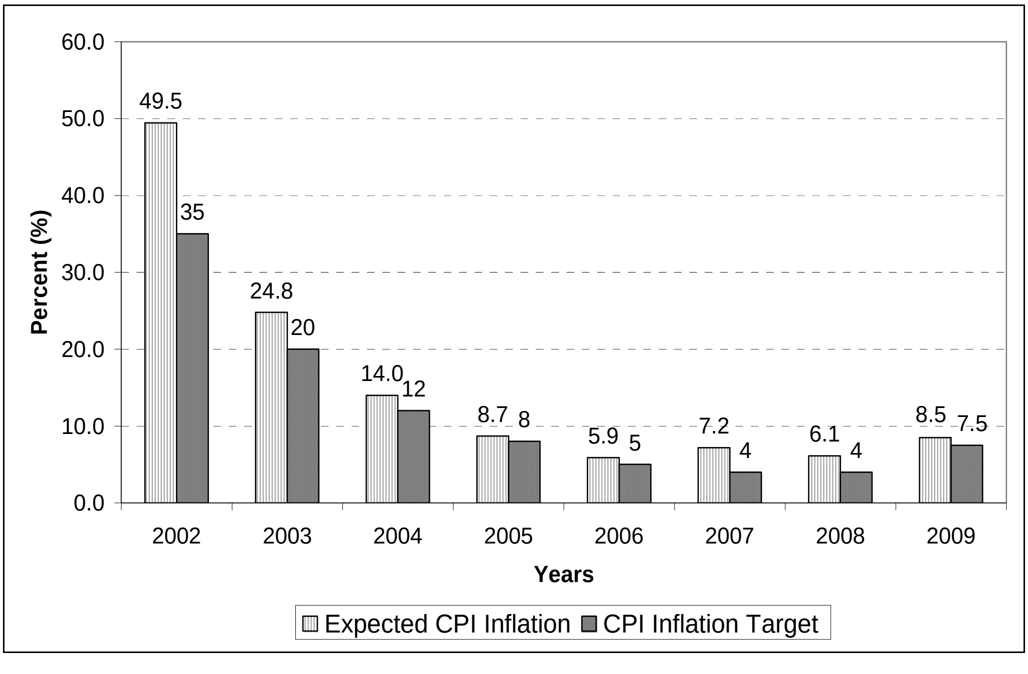
remained still high and this coupled with its sticky behavior continued to pose serious problems in managing inflation. However, in the aftermath of the 2000-01 crisis, unlike the 1994 crisis, the monetary regime was radically altered. An implicit inflation targeting regime was adopted starting in the period 2002-2005 and it was declared that Turkey would switch to a formal inflation targeting regime in 2006. As discussed above, these policies introduced in the aftermath of the 2000-01 crisis were successful in causing a relatively lower and more stable inflation environment in Turkey up to 2009. Therefore, in the next subsection we will investigate whether and how the structural parameters characterizing the inflation behavior have changed with economic agents facing this more favorable environment.

IV.B.8.4 Subsample Estimates

As discussed in the previous subsection, the introduction of the inflation targeting regime, whether implicit or fully fledged, was successful in terms of decreasing the inflation and its volatility in Turkey. However, a successful inflation targeting framework should also improve the credibility of the central bank and make current inflation more forward looking and less backward looking. Therefore, in this subsection, we will evaluate the success of this new policy regime in terms of its effect on backward and forward looking components of inflation. In other words, we will investigate whether with this new policy current inflation has become less inertial and the effect of the forward looking component on inflation has increased in magnitude. By doing so, we will be performing policy analysis using the open economy hybrid NKPC developed for Turkey as a tool.

Before conducting econometric analysis, first we have studied the effects of the inflation targeting framework introduced after the 2002 period on the credibility of the central bank. Following Kara (2008) we constructed a measure called the *policy credibility gap* that is defined as the difference between the expected and targeted inflation rates and plotted it for the period

2002-2009 in Figure 11. As this figure clearly reveals, during the 4 years implementation of the IITR, in the 2002-2005 period, the policy credibility gap has decreased in Turkey as people witnessed that inflation was realized at a rate lower than its targeted level (Figure 12). However, during the first three years implementation of the formal inflation targeting regime, in the 2006 – 2008 period, the inflation rates were realized at rates above their targeted levels, thereby causing the policy credibility gap to increase. Fortunately in 2009, the policy credibility gap again decreased with the fall of the realized inflation below its targeted level. Thus, during its first eight years implementation of the inflation targeting regime (whether implicit or formal), the central bank seems successful in terms of decreasing the policy credibility gap: In only 3 years out of 8 has the gap recorded an increase.



Note: Expectations for the next 12 months at the beginning of the year, Central Bank of the Republic of Turkey (CBRT) Survey of Expectations.

Figure 11 Policy Credibility Gap

Source: CBRT (2006, 2007, 2008, 2009, 2010a and 2010b)

After the descriptive analysis conducted above, we will now perform subsample GMM estimations to analyze formally whether the inflation targeting framework was credible in terms of increasing the forward looking component of inflation and decreasing the backward looking component. Results presented in the previous subsections had suggested that the short run inflation dynamics in Turkey for the period 1989-2009 can be analyzed using an open economy version of the hybrid NKPC. The forward (γ_f) and backward (γ_b) looking components of inflation were estimated around 0.46 and 0.53 for the Turkish economy suggesting that inflation was predominantly backward looking.

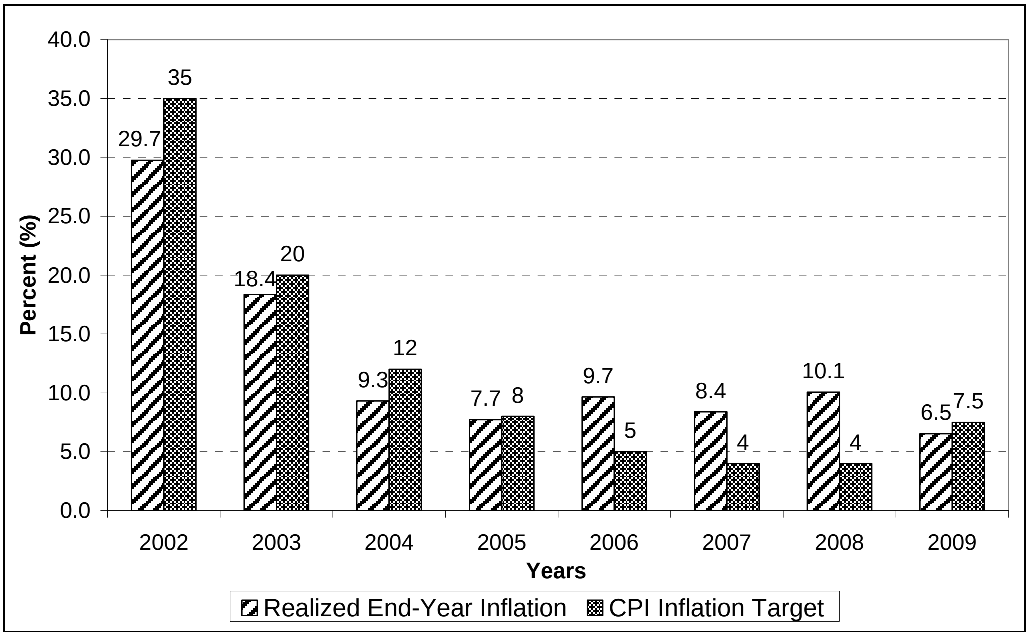


Figure 12 Realized and Targeted CPI Inflation

Sources: CBRT (2006, 2007, 2008, 2009, 2010a and 2010b) and author's own calculations.

Now we will analyze whether these estimates are altered with the transition to the inflation targeting regime starting in the year 2002 with the adoption of the implicit inflation targeting regime. Since the sample starting in 2002 would be relatively small for reliable inference, our exercise involves comparing the estimates of γ_f and γ_b obtained for the whole sample period with those obtained for the sub sample starting in 1988 and ending in 2001 - the year before the implicit inflation targeting regime was introduced[115]. We expect the estimate of γ_f to increase and the estimate of γ_b to decrease as we move from the subsample to the whole sample.

Table 11 reports the GMM estimation results of the structural parameters and the implied estimates of the reduced form parameters based on orthogonality conditions (4.4) and (4.5) for the sample period 1989 - 2001. Specifications 1 and 2 refer to equations (4.4) and (4.5), respectively. The instrument set is the same as that used in case of the whole data set. It includes a constant term and four lags of domestic price inflation, growth rate of USD-TL exchange rate, ratio of wages to import prices (i.e., $w_t - p_{F,t}$) and ratio of wages to domestic prices (i.e., $w_t - p_{H,t}$). The last four rows give the average duration of prices measured in months (denoted with D) and *p-values* of Hansen's test of overidentifying restrictions (J-test).

When Table 11 is analyzed, one can immediately note that all the estimated reduced and structural parameters have correct signs, are in the theoretically expected range and are statistically significant, in most cases at the 1 percent significance level. Second, in general, the estimates of reduced and structural form parameters are robust to different specifications of the moment conditions. Third, Hansen's J-test statistics reported in Table 12 do not reject the null hypothesis that the overidentifying moment conditions are valid and supported by the data.

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[115] The effective sample spans here the period 1989:1-2001:4 once allowance is made for the four lagged variables needed to construct the instrument set.

Table 11 GMM estimates of the reduced and structural form parameters for the period 1989 – 2001

Estimates of Structural Parameters[a]		
	Specification 1	**Specification 2**
θ	0.470*** (0.053)	0.493*** (0.112)
β	0.991*** (0.000)	0.991*** (0.000)
ω	0.683*** (0.010)	0.703*** (0.015)
ρ	-6.207*** (0.552)	-6.224*** (0.953)
γ	0.765*** (0.011)	0.674*** (0.031)
D	7.55	7.89
J-test	0.9552	0.3559
Estimates of Reduced Form Parameters[b]		
γ_f	0.405*** (0.027)	0.410*** (0.054)
γ_b	0.594** (0.027)	0.589*** (0.054)
λ_{mc}	0.010*** (0.003)	0.012* (0.006)
$\lambda_{loopgap}$	0.059*** (0.015)	0.044* (0.023)

Notes:
[a] The first part of this table presents the two-step GMM estimates of the structural form coefficients where the nonlinear two stage least squares estimator provides the initial consistent estimator.
[b] The second part of this table presents the implied estimates of the reduced form parameters calculated from equation (3.140) and their calculated standard errors. The standard errors of the reduced form parameters are computed according to Kmenta (1986).
[c] Asterisks (***,**,*) denote statistical significance at 1% , 5% and 10% levels, respectively.
[d] D denotes average price duration measured in months. See footnote 82 in text.
[e] The figures in parentheses are standard errors.
Source: Author's own calculations

When the results reported in Table 11 is compared to those in Table 1, it can be seen that regardless of which specification is used, the forward looking component of inflation has increased from 0.41 to about 0.46, while the backward looking component has decreased from 0.59 to about 0.53 when moving from the sub sample 1989-2001 to the whole sample 1989-2009. In case of specification 1 while the estimate of the forward looking coefficient has increased by 12 percent, the backward looking coefficient has decreased by 9 percent. For specification 2, the increase in the forward looking coefficient rises to 15 percent and the fall in the backward looking component increases to 10 percent. Therefore, we can conclude that the IT framework applied in Turkey after the 2002 period was overall successful in delivering an inflation rate that is relatively more forward looking and less inertial.

CHAPTER V

CONCLUSION

This thesis centers on the Phillips curve, which has always been one of the most important and controversial relations in macroeconomics. The Phillips curve has undergone recurrent revisions as macroeconomics has evolved with the introduction of rational expectations, intertemporal optimization and various rigidities. The traditional Phillips curve has been over the last decade challenged by the so-called 'New Keynesian Phillips Curve (NKPC)'. What new perspectives does the NKPC offer about inflation that has caused this challenge? The NKPC is even being proposed as the new consensus theory of inflation in modern monetary economics. But, why has the NKPC caused such a stir amongst economists and policy makers around the world? These two questions were the main starting point of this thesis.

After studying the NKPC paradigm, it is easy to see that its popularity mainly stems from its stringent explicit theoretical derivation from an optimizing model that is based on microeconomic principles. It has a striking feature when compared to the traditional backward looking Phillips curve: The inflation process has a *forward-looking* component. This feature is a consequence of the fact that in this framework firms facing constraints on the frequency of their price changes set prices in anticipation of future demand and cost conditions. In the *pure forward looking version* of the NKPC, current inflation is a function of expected future inflation and firms' real marginal cost. In the *hybrid version*, current inflation is also a function of past inflation. This feature that allows both backward and forward looking pricing behavior to be analyzed together within the inflation process is another important ingredient of the NKPC models. All these theoretical underpinnings motivated us to use the NKPC as a framework to analyze the Turkish inflation dynamics.

In Chapter II, we surveyed the vast literature on the NKPC by trying to give a picture of the many controversies surrounding the NKPC from its microfoundation to the type of estimation technique used. We discussed that the adaptation of the curve to an open economy framework increased the controversies because now the curve must give a good representation of the price, inflation and exchange rate dynamics. The results obtained when NKPC was applied to Turkish data were rather mixed. The few NKPC studies that are applied to Turkish data provide mixed evidence on the validity of this curve for the Turkish economy.

In contrast with the previous applications on the U.S. and the several Euro area countries, Yazgan and Yılmazkuday (2005) and Celasun et al. (2004a) have found empirical support for the *pure NPKC* specification. However, Celasun (2006) and Celasun et al. (2004b) have showed that the hybrid NPKC equation fits Turkish data quite well. Çatik et al. (2008) have showed that a *hybrid* Phillips curve á la Galí and Gertler (1999) exists for Turkey only if the variance and skewness of relative price changes are added to its specification. While Agénor and Bayraktar (2010) have found that the inflation process in Turkey is highly backward looking, Celasun (2006) and Celasun et al. (2004b) have showed that the forward looking component of Turkish inflation is statistically more important than the backward looking component.

We attributed this mixed evidence to the different modeling approaches used in those studies especially when open economy factors were introduced. Therefore, in this thesis to explain the inflation dynamics in Turkey within a theoretically consistent empirical framework, we attempted to derive an open economy NKPC equation for Turkey from a model that was possibly best suited for the Turkish economy.

Chapter III undertook this challenge and by combining a CES-type production function incorporating imported and domestically produced intermediate goods with *incomplete exchange rate pass through* in import prices developed a hybrid NKPC formulation that was *novel* in the literature. In this model, trade took place both at the intermediate and final goods production levels and deviations from the *law of one price (LOOP)* were allowed for the imported goods whether they are used as intermediate goods in production or final goods in consumption.

The short-run inflation dynamics in Turkey were analyzed within the context of this alternative NKPC specification by estimating the model's structural parameters that captured the price-setting behavior in Turkey in the period studied. The estimates of these parameters were then compared with those reported for other economies. In addition, the relative contribution of *past inflation* and *inflation expectations* in forming the inflation process in Turkey was assessed.

Chapter IV presented and evaluated the estimates of the NKPC equation for Turkey using a measure of real marginal cost and LOOP gap. We showed that each of the modifications made to the baseline NKPC model was crucial to improve the validity of the results. The results suggested that the estimates of the structural and reduced form parameters obtained from the NKPC model were in the theoretically plausible range and statistically significant.

We evaluated our model's performance in terms of its ability to explain the observed inflation dynamics in Turkey by constructing a model based measure of inflation namely, *fundamental inflation*. The results obtained were striking. For the period under consideration the inflation series based on our NKPC specification was quite successful in explaining *the 1994 and 2000-01 crisis* as well as the *current environment of low inflation* achieved with the adoption of the implicit and fully fledged inflation targeting regimes. Besides, our results suggested that that our open economy model that incorporated both domestically produced and imported intermediate inputs into the production function explained the actual inflation dynamics in Turkey better than did the closed economy model employing only labor and the open economy model without imported intermediate inputs. This particular evidence clearly demonstrates that the inclusion of imported intermediate goods and the introduction of incomplete exchange rate pass through in import prices have significantly improved the validity of our results. Thus, openness indeed matters for the modeling of inflation dynamics in a country like Turkey. Moreover, the closed economy model was showed to underestimate actual inflation behaviour uniformly across the entire estimation period for Turkey. This finding reveals that the usage of a closed economy model that does not take the effect of the imported goods prices on inflation into account may not be appropriate to model inflation dynamics in Turkey.

Our results on the structural parameter representing the degree of *price rigidity* indicated that in Turkey on average prices remained fixed for approximately *8 months*. This implied an average price duration that was *shorter* than that found for the United States, the Euro area aggregate, most of the individual Euro area countries, and the G7 countries. The lower and more stable inflation rate experienced in these countries was the probable cause of these less frequent optimal price adjustments. The estimation of the parameter representing the *intrinsic inflation inertia* suggested that 73 percent of all firms in Turkey followed the backward looking rule of thumb when setting their prices. This fairly high degree of inflation inertia when compared to those reported for the United States, Euro area and G7 countries were associated with Turkey's unfavorable history of high inflation. Even though Turkey adopted a fully fledged inflation targeting in 2006 to cure its chronic and high inflation after the collapse of the exchange rate based disinflation program supported by the IMF, it still faces a CPI inflation that is higher than most of the OECD countries. As for the reduced form coefficients of the model, the estimation results showed that still the *backward looking behavior* dominated the *forward looking behavior* in determining the inflation process in Turkey.

We then conducted a variety of robustness exercises. We studied whether the NKPC i) could explain the actual inflation behavior in Turkey, ii) outperformed an alternative closed economy model and an open economy model without imported intermediate inputs, iii) was robust to GMM estimation of the *closed form* and, iv) provides empirically relevant results using the *continuous updating GMM (CU-GMM)* estimation that is partially robust to weak instruments in the nonlinear models and has better finite sample properties than the *two step GMM estimator*.

These exercises showed that the open economy hybrid NKPC model developed was supported by the data when estimated by *continuous updating GMM* (CU-GMM) estimator, was robust to GMM estimation of the *closed form* and outperformed a closed economy model and an open economy model without imported intermediate inputs.

Furthermore we analyzed the *stability properties* of the curve for Turkey over the estimation period. Such an analysis was crucial for a country that has experienced major changes in its economic structure starting from the 1980s. The results of this exercise showed that the structural parameters of the NKPC were unstable over the estimation period, but this instability did not show itself as a model misspecification. The break points revealed themselves as the notorious 1994 and 2000-01 crisis. The 1994 crisis which was less severe than that of 2000-01 did not call for major policy actions. On the contrary, the implicit and formal inflation targeting regimes adopted after the 2000-01 crisis was successful in terms of decreasing the inflation and its volatility in Turkey and thereby providing a low and stable inflation environment for the economic agents in Turkey. Thus, the significant change in the monetary policy framework that occurred after the 2000-01 crisis can be seen as the major source of instability in the parameters of the model.

Therefore, finally we analyzed how the new policy framework adopted after the 2000-01 crisis affected the parameters characterizing the inflation process in Turkey. In other words, we performed policy analysis using the estimates obtained from the open economy hybrid NKPC specification developed for the

Turkish economy. We investigated whether the favorable inflation environment that resulted after the adoption of the inflation targeting framework caused changes in the structural and reduced form parameters characterizing the inflation process in Turkey. After all, a *successful* inflation targeting framework should enhance the credibility of monetary policy and make current inflation a function largely of *expected inflation*.

After 2005, however, many events that were not in the control of the central bank contributed to the increase in inflation expectations of the public. These events included the government delaying the appointment of the new central bank governor in 2006 and thereby creating doubts about the independence of the central bank from political influence, the rigorous political controversies surrounding the 2007 president elections, substantial increases in the world energy and food prices in 2007 and finally the 2007-2008 global financial crisis (Özatay, 2009). All the aforementioned events increased the uncertainty surrounding the markets, the credit risk of Turkey, the volatility of the exchange rate and interest rate, and the fragility of the economy to shocks thereby causing an increase in the inflation expectations of the public also in the policy credibility gap.

Despite the increase observed in the policy credibility gap for the 2006-2008 period, the subsample econometric results suggested that with the policies adopted in the post 2001 period, inflation in Turkey became *more* forward looking and *less* backward looking. Thus, for the period under study, the inflation targeting framework applied in Turkey was found successful in terms of decreasing *indexation* and inflation *inertia* in Turkey. The low and stable inflation environment facing the economic agents caused significant changes in the structural parameters characterizing the inflation process in Turkey. The observed decrease in backwardness could, in the future, decrease the sacrifice ratio since the less dominant is the backward-looking behavior the lower would be the output costs of a rapid disinflation. Also the decrease in the backward looking component could cause monetary policy to be more effective since the central bank would probably tighten monetary policy less to achieve a given inflation target. Thus, the policy implications for the future are that, should the success of the inflation targeting regime continue, this should be taken as an opportunity to reduce inflation substantially with very low output losses.

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APPENDICES

A1. TABLES

Table A.1 Unit root test results for the series used in GMM estimation for OEM2

	p	***ADF***	***LM(4)***
INF	16	-4.114***	4.515 (0.341)
F	17	-5.454***	4.418 (0.352)
Z	17	-5.973***	9.247 (0.055)
K	15	-6.197***	6.250 (0.181)
L	17	-5.098***	3.864 (0.425)
PDINF	16	-4.368***	1.878 (0.758)
W_P_H	17	-5.629***	4.341 (0.362)
W_P_F	17	-6.176***	7.790 (0.100)
GUSDTLER	0	-4.405***	3.632 (0.458)

Notes: 1. p denotes the number of lags included in the ADF test.
2. LM denotes the Breusch-Godfrey Lagrange multiplier test whose null hypothesis is that there is no serial corre*lation up to lag order h where in the present case h=4. It is asymptotically distributed as a chi-square distribution* with k degrees of freedom. The figure in parentheses gives the p-value of the LM test.
3. The tests are conducted in EVIEWS 5.1 which uses MacKinnon (1996) critical value calculations in constructing test output.
4. ***denotes rejection of the null hypothesis of a unit root at 1% significance level.
Source: Author's own calculations.

Table A.2 Unit root test results for MC and LOOPGAP series calculated from OEM2

	Variables	*p*	ADF	LM(4)
Specification 1	MC	12	-5.770***	5.594 (0.232)
	LOOPGAP	15	-6.601***	6.264 (0.394)
Specification 2	MC	12	-5.323***	4.004 (0.405)
	LOOPGAP	17	-3.765***	6.872 (0.333)

Notes: 1. p denotes the number of lags included in the ADF test.
2. LM denotes the Breusch-Godfrey Lagrange multiplier test whose null hypothesis is that there is no serial correlation up to lag order h where in the present case h=4. It is asymptotically distributed as a chi-square distribution with k degrees of freedom. The figure in parentheses gives the p-value of the LM test.
3. The tests are conducted in EVIEWS 5.1 which uses MacKinnon (1996) critical value calculations in constructing test output.
4. ***denotes rejection of the null hypothesis of a unit root at 1% significance level.
Source: Author's own calculations.

Table A.3 Residual Diagnostic test results for the VAR models chosen under specifications 1 and 2 for OEM2

	Specification 1 VAR(4)	Specification 1 VAR(5)	Specification 2 VAR(4)
Autocorrelation	19.814 (0.019)	10.438 (0.316)	6.241 (0.716)
Heteroscedasticity	151.951 (0.440)	183.777 (0.116)	244.925 (0.299)

Notes: 1. The autocorrelation test is conducted in EVIEWS 5.1 which reports the multivariate LM test statistics for residual serial correlation up to order h (equals to 4 in the present case).. Under the null hypothesis of no serial correlation of order h, the LM statistic is asymptotically chi-square distributed with k^2 degrees of freedom where k is the number of the endogenous variables included in the VAR. The figure in parentheses gives the p-value of the test.
2. The heteroscedasticity test is conducted in EVIEWS 5.1 which reports the multivariate extension of White's (1980) heteroscedasticity test (Boswijk and Doornik, 2004; Kelejian, 1982). Under the null hypothesis of homoscedastic residuals the test statistic is asymptotically chi-square distributed with *mn* degrees of freedom where m=(k(k+1)/2) is the number of cross-products of the residuals in the system and n is the number of the common set of right-hand side variables in the test regression.
Source: Author's own calculations.

Table A.4 VAR model estimates and diagnostics under specification 1 for OEM2

	MC	LOOPGAP	INF
MC(-1)	3.898 (0.093)	0.066 (0.290)	-0.721 (5.005)
MC(-2)	-6.680 (0.293)	0.389 (0.909)	4.622 (15.692)
MC(-3)	6.258 (0.411)	-1.278 (1.274)	-8.643 (21.995)
MC(-4)	-3.162 (0.297)	1.503 (0.921)	6.813 (15.905)
MC(-5)	0.673 (0.0964)	-0.664 (0.299)	-1.603 (5.162)
LOOPGAP(-1)	0.027 (0.03023)	3.845 (0.09373)	-0.182 (1.61841)
LOOPGAP(-2)	-0.134 (0.092)	-6.920 (0.287)	0.104 (4.948)
LOOPGAP(-3)	0.240 (0.13042)	7.073 (0.40441)	0.114 (6.98238)
LOOPGAP(-4)	-0.208 (0.095)	-4.110 (0.296)	-0.244 (5.107)
LOOPGAP(-5)	0.077 (0.032)	1.095 (0.100)	-0.156 (1.730)
INF(-1)	0.006 (0.002)	0.012 (0.007)	0.139 (0.121)
INF(-2)	0.003 (0.002)	0.009 (0.007)	0.294 (0.123)
INF(-3)	-0.002 (0.002)	-0.002 (0.007)	0.366 (0.119)
INF(-4)	-0.005511 (0.002)	-0.011091 (0.007)	0.075168 (0.124)
INF(-5)	-0.003 (0.002)	-0.009 (0.007)	0.129 (0.124)
C	0.048 (0.006)	0.069 (0.007)	0.037 (0.004)
R-squared	0.999621	0.999399	0.753821
Adj. R-squared	0.999536	0.999264	0.698706
Sum sq. resids	2.83E-05	0.000272	0.080973
S.E. equation	0.000649	0.002013	0.034764
F-statistic	11778.24	7427.002	13.67728
Log likelihood	500.2952	406.3701	169.9259
Akaike AIC	-11.66976	-9.406508	-3.709057
Schwarz SC	-11.20348	-8.940226	-3.242774
Mean dependent	-0.000871	-0.001969	0.096239
S.D. dependent	0.030147	0.074238	0.063334

Note: Standard errors are shown in parentheses.
Source: Author's own calculations.

Table A.5 VAR model estimates and diagnostics under specification 2 for OEM2

	MC	LOOPGAP	INF
MC(-1)	3.051 (0.077)	-0.167 (0.251)	1.364 (1.973)
MC(-2)	-4.047 (0.190)	0.892 (0.622)	-1.751 (4.879)
MC(-3)	2.738 (0.197)	-1.132 (0.644)	-0.241 (5.057)
MC(-4)	-0.783 (0.084)	0.672 (0.274)	1.227 (2.155)
LOOPGAP(-1)	0.047 (0.029)	3.137 (0.096)	-0.286 (0.754)
LOOPGAP(-2)	-0.141 (0.072)	-4.521 (0.234)	0.329 (1.838)
LOOPGAP(-3)	0.152 (0.073)	3.332 (0.240)	0.025 (1.886)
LOOPGAP(-4)	-0.069 (0.031)	-1.131 (0.103)	-0.377 (0.809)
INF(-1)	0.007 (0.005)	0.010 (0.015)	0.153 (0.118)
INF(-2)	0.005 (0.004)	0.010 (0.014)	0.338 (0.110)
INF(-3)	-0.002 (0.004)	-0.000 (0.014)	0.399 (0.112)
INF(-4)	-0.009 (0.005)	-0.013 (0.015)	0.091 (0.117)
C	-0.018 (0.004)	-0.039 (0.006)	-0.074 (0.008)
R-squared	0.998349	0.997457	0.746798
Adj. R-squared	0.998070	0.997027	0.704003
Sum sq. resids	0.000126	0.001356	0.083530
S.E. equation	0.001334	0.004370	0.034300
F-statistic	3577.937	2320.325	17.45067
Log likelihood	443.8920	344.2510	171.1705
Akaike AIC	-10.25933	-7.886929	-3.765965
Schwarz SC	-9.883136	-7.510731	-3.389768
Mean dependent	-0.000377	-0.000299	0.096613
S.D. dependent	0.030374	0.080134	0.063045

Note: Standard errors are shown in parenthesis.
Source: Author's own calculations.

Table A.6 Unit root test results for MC and LOOPGAP series calculated from CEM and OEM1

			WITHOUT CONSTANT OR TREND		
			p	**ADF**	**LM(4)**
CEM		**MC**	19	-4.782***	6.916 (0.140)
OEM1	**SPECIFICATION 1**	**MC**	12	-5.849***	8.305 (0.081)
		LOOPGAP	15	-6.926***	6.149 (0.188)
	SPECIFICATION 2	**MC**	12	-3.014***	7.486 (0.112)
		LOOPGAP	17	-2.669***	5.012 (0.286)

Notes: 1. p denotes the number of lags included in the ADF test.
2. LM denotes the Breusch-Godfrey Lagrange multiplier test whose null hypothesis is that there is no serial correlation up to lag order *h* where in the present case h=4. It is asymptotically distributed as a chi-square distribution with k degrees of freedom. The figure in parenthesis gives the p-value of the LM test.
3. The tests are conducted in EVIEWS 5.1 which uses MacKinnon (1996) critical value calculations in constructing test output.
4. ***,** denote rejection of the null hypothesis of a unit root at 1% and 5% significance levels.
Source: Author's own calculations.

Table A.7 Residual Diagnostic test results for the VAR model chosen for CEM

	VAR(4)	VAR(6)
Autocorrelation	5.702 (0.226)	3.459 (0.443)
Heteroscedasticity	157.130 (0.167)	210.167 (0.599)

Notes: 1. The autocorrelation test is conducted in EVIEWS 5.1 which reports the multivariate LM test statistics for residual serial correlation up to order *h* (equals to 4 in the present case).. Under the null hypothesis of no serial correlation of order *h*, the LM statistic is asymptotically chi-square distributed with k^2 degrees of freedom where *k* is the number of the endogenous variables included in the VAR. The figure in parenthesis gives the p-value of the test.
2. The heteroscedasticity test is conducted in EVIEWS 5.1 which reports the multivariate extension of White's (1980) heteroscedasticity test (Boswijk and Doornik, 2004; Kelejian, 1982). Under the null hypothesis of homoscedastic residuals the test statistic is asymptotically chi-square distributed with *mn* degrees of freedom where $m=(k(k+1)/2)$ is the number of cross-products of the residuals in the system and *n* is the number of the common set of right-hand side variables in the test regression.
Source: Author's own calculations.

Table A.8 Residual Diagnostic test results for the VAR models chosen under specifications 1 and 2 for OEM1

	Specification 1 VAR(5)	Specification 1 VAR(6)
Autocorrelation	18.364 (0.031)	11.925 (0.218)
Heteroscedasticity	107.633 (0.196)	159.070 (0.417)
	Specification 2 VAR(5)	**Specification 2 VAR(6)**
Autocorrelation	17.025 (0.048)	14.298 (0.112)
Heteroscedasticity	226.031 (0.412)	228.468 (0.369)

Notes: 1. The autocorrelation test is conducted in EVIEWS 5.1 which reports the multivariate LM test statistics for residual serial correlation up to order *h* (equals to 4 in the present case). Under the null hypothesis of no serial correlation of order *h*, the LM statistic is asymptotically chi-square distributed with k^2 degrees of freedom where *k* is the number of the endogenous variables included in the VAR. The figure in parenthesis gives the p-value of the test.
2. The heteroscedasticity test is conducted in EVIEWS 5.1 which reports the multivariate extension of White's (1980) heteroscedasticity test (Boswijk and Doornik, 2004; Kelejian, 1982). Under the null hypothesis of homoscedastic residuals the test statistic is asymptotically chi-square distributed with *mn* degrees of freedom where $m=(k(k+1)/2)$ is the number of cross-products of the residuals in the system and *n* is the number of the common set of right-hand side variables in the test regression.
Source: Author's own calculations.

Table A.9 VAR model estimates and diagnostics for CEM

	INF	MC
INF(-1)	0.216 (0.116)	-0.005 (0.018)
INF(-2)	0.331 (0.111)	-0.010 (0.017)
INF(-3)	0.350 (0.112)	-0.001 (0.017)
INF(-4)	0.051 (0.116)	0.017 (0.018)
MC(-1)	-0.258 (0.280)	3.272 (0.043)
MC(-2)	0.376 (0.726)	-4.568 (0.111)
MC(-3)	0.015 (0.737)	3.211 (0.113)
MC(-4)	-0.129 (0.290)	-0.960 (0.045)
C	0.052 (0.008)	-0.012 (0.001)
R-squared	0.721734	0.998864
Adj. R-squared	0.692053	0.998743
Sum sq. resids	0.091798	0.002158
S.E. equation	0.034985	0.005364
F-statistic	24.315830	8244.829000
Log likelihood	167.206300	324.728500
Akaike AIC	-3.766817	-7.517345
Schwarz SC	-3.506372	-7.256900
Mean dependent	0.096613	-0.007541
S.D. dependent	0.063045	0.151291

Note: Standard errors are shown in parenthesis.
Source: Author's own calculations.

Table A.10 VAR model estimates and diagnostics under specification 1 for OEM1

	MC	LOOPGAP	INF
MC(-1)	4.6285 (0.0590)	-0.9245 (0.5744)	5.7580 (17.4366)
MC(-2)	-9.9037 (0.2313)	2.4161 (2.2510)	-3.0626 (68.3288)
MC(-3)	12.3686 (0.4140)	-2.3977 (4.0296)	-13.3761 (122.3170)
MC(-4)	-9.4585 (0.4170)	0.2490 (4.0593)	30.0919 (123.2195)
MC(-5)	4.1889 (0.2365)	1.2673 (2.3023)	-27.1031 (69.8848)
MC(-6)	-0.8446 (0.0617)	-0.8147 (0.6009)	12.0300 (18.2394)
LOOPGAP(-1)	-0.0188 (0.0066)	4.5789 (0.0639)	0.6272 (1.9411)
LOOPGAP(-2)	0.0723 (0.0254)	-9.8482 (0.2471)	0.7783 (7.4995)
LOOPGAP(-3)	-0.1257 (0.0449)	12.4992 (0.4371)	-5.1813 (13.2669)
LOOPGAP(-4)	0.1230 (0.0449)	-9.8546 (0.4371)	8.8716 (13.2684)
LOOPGAP(-5)	-0.0675 (0.0253)	4.5927 (0.2467)	-7.0399 (7.4876)
LOOPGAP(-6)	0.0162 (0.0066)	-1.0089 (0.0640)	2.3787 (1.9423)
INF(-1)	-0.0006 (0.0004)	0.0023 (0.00419	-0.0133 (0.1242)
INF(-2)	-0.0011 (0.0004)	0.0019 (0.0040)	0.2098 (0.1222)
INF(-3)	-0.0003 (0.0004)	-0.0007 (0.0042)	0.3080 (0.1261)
INF(-4)	0.0007 (0.0004)	-0.0031 (0.0042)	0.1220 (0.1270)
INF(-5)	0.0010 (0.0004)	-0.0023 (0.0041)	0.1892 (0.1247)
INF(-6)	0.0005 (0.0004)	0.0001 (0.0041)	0.2477 (0.1251)
C	-0.0027 (0.0006)	0.0024 (0.0005)	-0.0426 (0.0089)
R-squared	0.999929	0.999897	0.787389
Adj. R-squared	0.999907	0.999867	0.723606

Table A.10 (continued)

Sum sq. resids	0.000001	0.000071	0.065854
S.E. equation	0.000112	0.001091	0.033130
F-statistic	46688.473697	32509.516692	12.344775
Log likelihood	617.344247	437.572325	167.949316
Akaike AIC	-15.147956	-10.596768	-3.770869
Schwarz SC	-14.578088	-10.026901	-3.201002
Mean dependent	0.000190	-0.003256	0.099095
S.D. dependent	0.011639	0.094538	0.063016

Note: Standard errors are shown in parenthesis.
Source: Author's own calculations.

Table A.11 VAR model estimates and diagnostics under specification 2 for OEM1

	MC	**LOOPGAP**	**INF**
MC(-1)	4.4780 0.0475	1.6243 0.5639	-1.4123 21.8646
MC(-2)	-9.4007 0.1856	-7.5482 2.2047	29.4914 85.4872
MC(-3)	11.5941 0.3330	15.4217 3.9560	-74.9232 153.3906
MC(-4)	-8.8087 0.3376	-17.7397 4.0111	94.5526 155.5289
MC(-5)	3.8943 0.1932	11.4736 2.2954	-64.4371 89.0020
MC(-6)	-0.7885 0.0512	-3.4920 0.6087	21.7399 23.6036
LOOPGAP(-1)	-0.0247 0.0040	4.5125 0.0480	2.8882 1.8607
LOOPGAP(-2)	0.0955 0.0154	-9.5718 0.1828	-8.4450 7.0892
LOOPGAP(-3)	-0.1662 0.0269	11.9642 0.3198	11.7113 12.3999
LOOPGAP(-4)	0.1623 0.0265	-9.2697 0.3153	-8.6635 12.2242
LOOPGAP(-5)	-0.0884 0.0147	4.2263 0.1750	3.3170 6.7845
LOOPGAP(-6)	0.0215 0.0037	-0.9022 0.0443	-0.5850 1.7160

Table A.11 (continued)

INF(-1)	-0.0010 0.0003	0.0037 0.0032	-0.0372 0.1260
INF(-2)	-0.0009 0.0003	0.0058 0.0033	0.1869 0.1269
INF(-3)	-0.0003 0.0003	0.0036 0.0033	0.3087 0.1289
INF(-4)	0.0007 0.0003	-0.0022 0.0033	0.1410 0.1277
INF(-5)	0.0010 0.0003	-0.0061 0.0033	0.2028 0.1283
INF(-6)	0.0006 0.0003	-0.0056 0.0034	0.2348 0.1311
C	-0.0022 0.0004	0.0016 0.0004	-0.0096 0.0037
R-squared	0.999949	0.999933	0.791143
Adj. R-squared	0.999934	0.999913	0.728486
Sum sq. resids	0.000000	0.000043	0.064692
S.E. equation	0.000071	0.000847	0.032836
F-statistic	65752.769892	49864.924989	12.626532
Log likelihood	653.134707	457.616168	168.652883
Akaike AIC	-16.054043	-11.104207	-3.788681
Schwarz SC	-15.484176	-10.534340	-3.218813
Mean dependent	0.000010	-0.003120	0.099095
S.D. dependent	0.008780	0.090845	0.063016

Note: Standard errors are shown in parenthesis.
Source: Author's own calculations.

A2. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name:	Eruygur, Ayşegül
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EDUCATION

Degree	**Institution**	**Year of Graduation**
MS	METU Economics	2003
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High School	T.E.D. Ankara College, Ankara	1996

WORK EXPERIENCE

Year	**Place**	**Enrollment**
2010 - Present	Çankaya University Department of Economics	Part-time Lecturer
2001- 2008	METU Department of Economics	Teaching and Research Assistant
1999 August	Undersecretariat of Treasury	Intern Student
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FOREIGN LANGUAGES

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PUBLICATIONS

KAYNAK, M., ERUYGUR, A, and MERT, M. (2009), "Transportation-Communication Investment and Economic Growth: A VECM Analysis for Turkey", Paper submitted to *European Planning Studies* (indexed in SSCI) (Accepted).

SOFTWARE KNOWLEDGE

Microsoft Office, WinRATS, Stata, E-Views, Gretl, Matlab.

A3. TURKISH SUMMARY

Bu çalışma makroekonomi yazınının en önemli ve en çok tartışılan ilişkilerinden biri olan Phillips eğrisi üzerine yoğunlaşmıştır. Makroekonomi alanı; rasyonel beklentiler, zamanlararası optimizasyon ve birçok katılığın girmesiyle birlikte geliştikçe, Phillips eğrisi üst üste revizyonlar geçirmiştir. Son on yılı aşkın bir zamandan beri ise Geleneksel Phillips eğrisine, *Yeni Keynesgil Phillips Eğrisi* (New Keynesian Phillips Curve, NKPC) meydan okumaktadır. Enflasyon hakkında Yeni Keynesgil Phillips Eğrisi, bu meydan okumaya yol açan, hangi değişik bakış açılarını önermektedir? Yeni Keynesgil Phillips Eğrisi'nin modern makroekonomi yazınının fikir birliğine varılan yeni enflasyon kuramı olduğu bile ileri sürülmüştür. Peki dünyanın dört bir tarafındaki ekonomistler ve politikacılar arasında Yeni Keynesgil Phillips Eğrisi neden bu kadar çok tartışmaya sebep olmuştur? Bu iki soru bu tezin en temel iki başlangıç noktasını oluşturmaktadır.

Bu tezin esas amacı Türkiye'deki enflasyon dinamiklerini teorik olarak tutarlı bir ampirik çerçevede açıklayabilmektir. Yeni Keynesgil Phillips Eğrisi de bu analizin dayandığı temel model olarak seçilmiştir. Yeni Keynesgil Phillips Eğrisi, enflasyon sürecini; aksak rekabetçi olarak tanımlanan firmaların fiyatlarını belirlerken kısıtlarla karşılaştığı dinamik bir genel denge modeli yapısı içinde tanımlar. Yeni Keynesgil Phillips Eğrisi bu şekilde mikroekonomik ilkelere dayanan bir optimizasyon modelinden türetildiğinden makroekonomi literatüründe çok tutulan bir model olmuştur. Geleneksel Phillips eğrisiyle kıyaslandığında, Yeni Keynesgil Phillips Eğrisi'nin dikkat çekici bir özelliği vardır: enflasyon süreci *ileriye-dönük* (forward-looking) bir bileşene sahiptir. Bu nitelik, Yeni Keynesgil Phillips Eğrisi yapısında firmaların fiyat değiştirme sıklıklarında kısıtlarla karşı karşıya kaldıklarında, fiyatlarını gelecekte oluşabilecek talep ve maliyet koşullarına ilişkin öngörüleriyle belirlemelerinin bir sonucudur. Yeni Keynesgil Phillips Eğrisi'nin *katıksız* ileriye-dönük (pure forward-looking) biçiminde cari enflasyon, gelecekte beklenen enflasyonun ve firmaların reel marjinal maliyetlerinin bir fonksiyonudur. Eğrinin *melez* (hybrid) biçiminde ise; cari enflasyon geçmiş enflasyonun da bir fonksiyonudur. Yeni Keynesgil Phillips Eğrisi modelinin bir diğer önemli özelliği de sahip olduğu bu yapının, hem *geçmişe-dönük* (backward-looking) hem de *ileriye-dönük* (forward-looking) fiyatlama davranışlarının enflasyon süreci içinde birlikte incelenmesine olanak tanımasıdır. Bütün bu yukarıda saymış olduğumuz teorik destekleyici unsurlar bizi Türkiye'deki enflasyon dinamiklerini incelemek üzere Yeni Keynesgil Phillips Eğrisi'ni temel model olarak kullanmamız için motive etmiştir.

II. Bölümde oldukça geniş olan Yeni Keynesgil Phillips Eğrisi literatürü; Yeni Keynesgil Phillips Eğrisi'nin mikroekonomik temellerinden, bu eğriyi tahmin etmek için kullanılacak yöntemlere kadar olan bir çok tartışmayı gözler önüne serecek biçimde incelenmiştir. Ayrıca bu bölümde Yeni Keynesgil Phillips Eğrisi'nin *açık ekonomilere* (open economy) uyarlanmasının bu tartışmaları arttırdığı da gözler önüne serilmiştir. Bunun altında yatan temel sebep açık ekonomi çerçevesine geçildiğinde; Yeni Keynesgil Phillips Eğrisi'nin artık sadece fiyat ve enflasyonu değil, döviz kuru dinamiklerini de iyi bir şekilde temsil etmesinin gerekliliğidir. Yeni Keynesgil Phillips Eğrisi'nin Türkiye uygulamaları bu eğrinin Türkiye'ye uygulanabilirliği ve geçerliliğiyle ilgili oldukça çelişkili sonuçlar vermektedir.

Amerika ve Avrupa Birliği ülkeleri gibi gelişmiş ülkelere yapılan uygulamalarda elde edilen sonuçların tam tersine; Yazgan ve Yılmazkuday (2005) ve Celasun, Gelos ve Prati (2004a), *katıksız* ileriye-dönük (pure forward-looking) Yeni Keynesgil Phillips Eğrisi biçiminin Türkiye verisi tarafından desteklendiği sonuca varmışlardır. Celasun (2006) ile Celasun, Gelos ve Prati (2004b) ise Yeni Keynesgil Phillips Eğrisi'nin *melez* biçiminin Türkiye verisine oldukça iyi uyduğunu göstermişlerdir. Diğer taraftan; Çatik, Martin ve Önder (2008) ise; Galí ve Gertler (1999) tarzında melez bir Yeni Keynesgil Phillips Eğrisi'nin ancak göreli fiyat değişikliklerinin varyans ve çarpıklığı (skewness) bu denklemin içine katılırsa mevcut olabileceğini bulmuşlardır. Agénor ve Bayraktar (2010); Türkiye'deki enflasyon sürecinin oldukça geçmişe-dönük (backward-looking) olduğunu gösterirken, Celasun (2006) ve Celasun *ve ark.* (2004b) ise enflasyonun ileriye-dönük (forward-looking) bileşeninin geçmişe-dönük (backward-looking) bileşeninden istatistiksel olarak daha anlamlı olduğunu bulmuşlardır.

Yeni Keynesgil Phillips Eğrisi'nin Türkiye uygulamalarına ilişkin yukarıda bahsedilen çelişkili sonuçlar özellikle, bu çalışmalarda açık ekonomiyi tanımlayan etmenlerin Yeni Keynesgil Phillips Eğrisi'ne dahil ediliş şekline göre oluşan farklı model yapılarına atfedilmiştir. Nitekim, Yazgan ve Yılmazkuday (2005)'in çalışmasında Türkiye'deki enflasyonu modellemek için Galí ve Gertler (1999)'in *katıksız* ileriye-dönük (pure forward-looking) ve *melez* kapalı ekonomi modelleri kullanılmıştır. Buna karşın, Celasun *ve ark.* (2004a, 2004b) ile Agénor ve Bayraktar (2010); Galí and Gertler (1999)'un *indirgenmiş biçim* (reduced form) melez Yeni Keynesgil Phillips Eğrisi denklemine herhangi bir teorik model çözümünden gelmeyen bazı açık ekonomi değişkenleri eklemişlerdir. Celasun (2006) ise Türkiye için kullandığı Yeni Keynesgil Phillips Eğrisi denklemini mikro tabanlı bir genel denge modelinden türettiği için bu çalışmalardan ayrışmaktadır. Fakat Türkiye ile ilgili çalışmalarda *Tek Fiyat Yasası* (Law of One Price, LOOP) ampirik bulgularla desteklenmemesine rağmen, Celasun (2006) çalışmasında *Tek Fiyat Yasası'nın* Türkiye için ticarete konu olan mallarda geçerli olduğunu varsaymıştır. Celasun (2006)'nın tartışmaya açık bir diğer varsayımı da ticarete konu olmayan malların sadece işgücü kullanılarak üretildiğidir. Bu yüzden, bu çalışmada Türkiye'deki enflasyon dinamiklerini teorik olarak tutarlı bir çerçevede açıklayabilmek için; Türkiye'nin ekonomik yapısına mümkün olduğunca en iyi uyan modeli kullanarak Türkiye için bir açık ekonomi Yeni Keynesgil Phillips Eğrisi denklemi türetmeyi hedefledik.

III. Bölümde bu önemli sorunu çözmek amaçlanmıştır. Bu amaçla, ithal ve yerli ara malları içeren *sabit ikame esnekliği* (Constant elasticity of substitution, CES) tipi bir üretim fonksiyonu, ithal mallarda *tam-olmayan döviz kuru geçişkenliği* (incomplete exchange rate pass-through) ile birleştirilerek;

yeni bir Yeni Keynesgil Phillips Eğrisi formülasyonu geliştirilmiş ve literatüre bu şekilde katkıda bulunulmuştur. Bu yeni geliştirilen modelde ticaret; hem ara mallar hem de nihai mallar düzeylerinde yapılmaktadır. Ayrıca ithal ara mallarda, nihai ya da ara malı olarak kullanılmalarına bakılmaksızın, *Tek Fiyat Yasası'ndan* (Law of One Price, LOOP) sapmalara izin verilmiştir. Ampirik bulgular ithal malı fiyatlarına kur geçişkenliğinin tam olmadığını gösterdikleri halde; Türkiye için yapılmış çalışmaların hiçbirinde bu özelliğe yer verilmemiş ve dolayısıyla da ithal malı fiyatlama kararı modellenememiştir. Bunun yanı sıra, Türkiye'ye uygulanan Yeni Keynesgil Phillips Eğrisi modellerinde üretim sadece emeğin üretim faktörü olduğu doğrusal Cobb-Douglas fonksiyonu kullanılarak modellenmiştir. Bu açıdan bakıldığında da, tezde kullanılan ve ara mallarını da içeren CES tipi üretim fonksiyonu Türkiye literatüründeki diğer çalışmalardan önemle ayrılır.

Türkiye'deki kısa dönemli enflasyon dinamikleri; bu yeni spesifikasyon çerçevesinde, modelin oldukça doğrusal-olmayan ve Türkiye'deki fiyat belirleme davranışlarını yakalayan yapısal parametreleri tahmin edilerek incelenmiştir. Tahminler 1988:1 – 2009:4 dönemi için iki *aşamalı genelleştirilmiş beklemler yöntemi* tahmincisi (Two-step Generalized Method of Moments estimator, 2-step GMM estimator) kullanılarak yapılmıştır. Tahmin edilen parametreler daha sonra diğer ülkeler için rapor edilmiş değerlerle kıyaslanmıştır. Ayrıca, geçmiş enflasyon ve enflasyon beklentilerinin Türkiye'deki enflasyon sürecinin oluşmasındaki göreli katkıları değerlendirilmiştir.

IV. Bölümde ise Türkiye için türetilen Yeni Keynesgil Phillips Eğrisi denklemi parametrelerinin tahminleri sunulmuş ve değerlendirmiştir. Yeni Keynesgil Phillips Eğrisi temel modeline yapılan her modifikasyonun (ithal mallarda Tek Fiyat Yasası'ndan - Law of One Price, LOOP - sapma ile ithal ve yerli ara malı içeren bir üretim fonksiyonu kullanılması gibi) sonuçların doğruluğunu ve geçerliliğini geliştirmek için çok önemli olduğu gösterilmiştir. Sonuçlar, Yeni Keynesgil Phillips Eğrisi modelinden elde edilen yapısal ve indirgenmiş biçim parametre tahminlerinin teorik olarak uygun aralıkta ve istatistiksel olarak anlamlı olduklarını göstermiştir.

Türkiye için özel olarak yapılandırılan ve türetilin Yeni Keynesgil Phillips Eğrisi denkleminin gerçekte gözlemlenen enflasyon dinamiklerini açıklamaktaki başarısı, *temel-enflasyon* (fundamental inflation) adı verilen model tabanlı bir enflasyon ölçütü oluşturularak değerlendirilmiştir. Elde edilen sonuçlar oldukça dikkat çekicidir. Analizin yapıldığı dönem için Yeni Keynesgil Phillips Eğrisi modelinden elde edilen enflasyon serisi hem 1994 ve 2000-01 krizlerini hem de örtük ve açık enflasyon hedeflemesi politikalarına geçilmesiyle birlikte günümüzde yaşanan düşük enflasyon ortamını açıklamakta oldukça başarılıdır. Buna ek olarak, üretim fonksiyonunda hem ithal ve hem de yerli ara mallara yer veren yeni türettiğimiz açık ekonomi Yeni Keynesgil Phillips Eğrisi modeli gerçekte gözlemlenen enflasyonu açıklamada, üretim faktörü olarak sadece emeği kullanan bir kapalı ekonomi Yeni Keynesgil Phillips Eğrisi modelinden ve ithal ara mallarını içermeyen bir açık ekonomi Yeni Keynesgil Phillips Eğrisi modeli varyantından daha başarılıdır. Bu bulgu açıkça göstermiştir ki üretim fonksiyonunun ithal ara malları içermesi ve ithal mallarda *tam-olmayan döviz kuru geçişkenliği* (incomplete exchange rate pass through) gibi özellikler sonuçların geçerliliğini kesinlikle daha iyi hale getirmiştir. Dolayısıyla, Türkiye gibi bir ülkenin enflasyon dinamiklerini modellerken *açıklık* (openness), yani ülkenin açık bir ekonomi olarak modellenmesi gerçekten çok önem taşımaktadır. Dahası, kapalı ekonomi modeli bütün tahmin dönemi boyunca gerçekte gözlenen enflasyonu genel olarak olduğu değerden hep daha küçük tahmin etmiştir. Bu sonuç Türkiye'nin enflasyon dinamiklerini modellerken, ithal malların enflasyon üzerindeki etkisini göz ardı eden kapalı bir ekonomi modelinin kullanılmasının ne kadar sakıncalı olabileceğini açıkça göstermektedir.

Fiyat katılığını (price rigidity) temsil eden yapısal parametre ile ilgili bulgular, Türkiye'de fiyatların ortalama 8 ay sabit kaldığını göstermiştir. Bulunan bu *ortalama fiyat sürekliliği* (average price duration); Amerika, G7 ülkeleri, Avro

Alanı ve pek çok Avrupa birliği ülkesi için literatürde karşılaşılan değerlerden daha kısadır. Bu ülkelerde gözlemlenen optimal fiyat uyarlanmasının daha az sık (veya daha seyrek) gerçekleşmesi bahsi geçen ülkelerdeki daha düşük ve istikrarlı seyreden enflasyonun olası bir sonucudur. *İçsel-varolan enflasyon ataletini* (intrinsic inflation inertia) gösteren parametrenin tahmini Türkiye'deki tüm firmaların yüzde 73'ünün geçmişe-dönük fiyatlama kuralını takip ettiklerini işaret etmektedir. Amerika, G7 ülkeleri ve Avro Alanı ile kıyaslandığında oldukça yüksek olan bu enflasyon ataleti Türkiye'nin yüksek enflasyon tarihi ile ilişkilendirilebilir. Türkiye, kura dayalı stabilizasyon programının çöküşünden sonra kronik ve yüksek seyreden enflasyon sorununu çözmek için 2006 yılından itibaren açık enflasyon hedeflemesine geçmesine rağmen, halen pek çok OECD ülkesinde gözlenenden daha yüksek bir TÜFE enflasyonuyla karşı karşıyadır. Modelin indirgenmiş biçim parametre tahminlerinin sonuçları ise; Türkiye'deki enflasyon sürecini belirlemekte, geçmişe-dönük enflasyon davranışının ileriye-dönük enflasyon davranışından daha baskın olduğunu göstermiştir.

Çalışmamızda, Türkiye için geliştirdiğimiz Yeni Keynesgil Phillips Eğrisi modelinin *dirençliliğini* (robustness) değerlendirmek için de bir çok çözümleme de bulunduk. İlk olarak Yeni Keynesgil Phillips Eğrisi'nin gerçekte gözlenen enflasyon davranışını açıklamaktaki başarısını inceledik. Sonraki aşamada geliştirdiğimiz Yeni Keynesgil Phillips Eğrisi modelinin, iki alternatif model olan kapalı ekonomi ve ithal ara mallarını içermeyen açık ekonomi modellerinden daha iyi çalışıp çalışmadığını araştırdık. Daha sonra ise *kapalı biçimin* (closed form) *genelleştirilmiş beklemler yöntemi* (Generalized Method of Moments, GMM) ile tahminine *dirençli* (robust) olup olmadığını analiz ettik. Son olarak da geliştirdiğimiz Yeni Keynesgil Phillips Eğrisi modelinin *sürekli güncellenen genelleştirilmiş beklemler yöntemi* (Constantly updated GMM, CU-GMM) ile tahmin edildiğinde de anlamlı ampirik sonuçlar üretip üretmediğini inceledik. Bilindiği gibi, *sürekli güncellenen genelleştirilmiş beklemler yöntemi* (CU-GMM) doğrusal-olmayan modellerde zayıf-araçlara kısmi olarak *dirençlidir* (robust). Ayrıca bu metod, iki aşamalı genelleştirilmiş beklemler yöntemi tahmincisinden daha üstün sonlu-örneklem özelliklerine sahiptir.

Yukarıda bahsedilen incelemelerin sonucunda, Türkiye için geliştirdiğimiz Yeni Keynesgil Phillips Eğrisi modelinin sürekli güncellenen genelleştirilmiş beklemler yöntemi (CU-GMM) tahmincisi ile tahmin edildiğinde de veri ile desteklendiğini ve *kapalı-biçimin* (closed-form) genelleştirilmiş beklemler yöntemi (GMM) ile tahminine *dirençli* (robust) olduğunu gördük. Ayrıca modelin kapalı ekonomi ve ithal ara malları içermeyen açık ekonomi modellerinden daha iyi sonuçlar verdiğini gösterdik.

Yukarıda bahsedilen noktalara ek olarak; geliştirdiğimiz Yeni Keynesgil Phillips Eğrisi denkleminin tahmin dönemi boyunca kararlı olup olmadığı da *genelleştirilmiş beklemler yöntemi* (GMM) çerçevesinde önerilen kararlılık testleri kullanılarak sınanmıştır. Böyle bir analiz özellikle Türkiye gibi ekonomik yapısında 1980'lerden beri bir çok ciddi değişiklikler yaşamış bir ülke için oldukça önemlidir. Bu çalışmanın sonuçları geliştirdiğimiz Yeni Keynesgil Phillips Eğrisi modelinin yapısal parametrelerinin kararlı olmadığını işaret etmektedir. Fakat test sonuçları göstermektedir ki bu durum modelin yanlış spesifikasyonundan kaynaklanmamaktadır. Kırılım noktaları kendilerini 1994 ve 2000-01 krizleri olarak göstermiştir. 2000-01 krizine kıyasla daha az şiddetli geçen 1994 krizinde büyük politika değişiklerine gerek duyulmamıştır. Bunun tam tersi olarak, 2000-01 krizinden sonra ise örtük ve açık enflasyon hedeflemesine geçilmiştir. Bu büyük makro politika değişiklikleri ise Türkiye'deki enflasyonun düzeyini ve *oynaklığını* (volatility) düşürmekte oldukça başarılı olmuştur. Böylece de ülkede yaşayan ekonomik birimler için düşük ve istikrarlı bir enflasyon ortamı sağlanmıştır. Dolayısıyla, para politikası çerçevesinde 2000-01 krizinden sonra ortaya çıkan önemli değişimler, modelin parametrelerindeki kararsızlığın en önemli açıklayıcısı olarak düşünülebilir.

Buradan hareketle, son olarak ise, 2000-01 krizinden sonra uygulanmaya başlanan bu yeni para politikası yapısının, Türkiye'deki enflasyon sürecini niteleyen parametreleri nasıl etkilediğini araştırdık. Başka bir deyişle, Türkiye için geliştirdiğimiz *açık ekonomi melez Yeni Keynesgil Phillips Eğrisi* modelinin tahminlerini kullanarak *politika analizi* (policy analysis) gerçekleştirdik. Enflasyon hedeflemesine geçildikten sonra oluşan olumlu enflasyon atmosferinin modelimizin yapısal ve indirgenmiş biçim parametreleri üzerinde değişikliğe yol açıp açmadığını araştırdık. Çünkü herşeyden önce, başarılı bir enflasyon hedeflemesi uygulaması para politikasının güvenilirliğini artırmalı ve böylece de cari enflasyonu, geçmiş enflasyonun (ya da ataletin) değil daha çok gelecek enflasyonun bir fonksiyonu haline getirmelidir.

Diğer taraftan, 2005 yılı sonrasında, Merkez Bankasının kontrolünde olmayan birçok olay halkın enflasyon beklentisinin artmasına sebep olmuştur. Bu olaylardan ilki 2006 yılında Merkez Bankası başkanının atanması sürecinde meydana gelen gecikmedir. Bu durum merkez bankasının siyasal otoriteden bağımsızlığı noktasında şüpheler oluşmasına sebep olmuştur. Bir başka olay ise 2007 yılında gerçekleşen Cumhurbaşkanlığı seçimlerinde oluşan sert politik ortamdır. Aynı yıl, yani 2007'de enerji ve gıda fiyatlarında da önemli artışlar meydana gelmiştir. Bu olayların sonuncusu ise, 2007-2008 yıllarında meydana gelen küresel finansal kriz olmuştur (Özatay, 1999). Bütün bu yukarıda bahsedilen olaylar piyasalardaki belirsizliği, Türkiye'nin kredi riskini, kur ve faizdeki oynaklığı ve ekonominin şoklara karşı olan kırılganlığını arttırarak halkın enflasyon beklentilerinde artışa yol açmıştır. Bu da beklenen ile hedef enflasyon farkı olarak tanımlanan *politika güvenirlilik açığını* (policy credibility gap) arttırmıştır.

2006-2008 döneminde *politika güvenirlilik açığınında* gözlemlenen artışa rağmen, alt örneklem üzerinden ekonometrik sonuçlar göstermektedir ki Türkiye'de uygulanan enflasyon hedeflemesi politikaları hem enflasyondaki ataleti düşürmede hem de enflasyonu ileriye dönük hale getirmede başarılı olmuşlardır. Ekonomik birimlerin karşılaştıkları düşük ve istikrarlı seyreden enflasyon ortamı enflasyon sürecini niteleyen yapısal parametrelerde istatistiksel olarak anlamlı değişikliklere yol açmıştır. Geçmişe dönük fiyatlama davranışındaki bu düşme ise gelecek dönemde *fedakarlık oranında* bir düşüşe sebep olabilir. Çünkü geçmişe-dönük fiyatlama davranışı ne kadar az baskın olursa enflasyonu hızlı bir şekilde düşürmenin çıktı maliyeti de bir o kadar az olacaktır. Ayrıca, enflasyonun geçmişe-dönük bileşenindeki bu düşüş para politikasının da daha etkin olmasına yol açabilir. Çünkü Merkez Bankası veri bir enflasyon hedefini gerçekleştirmek için büyük olasılıkla para politikasını daha az daraltacaktır. Bütün bunların gelecek için öngördüğü *politika önermesi* (policy implication) ise enflasyon hedeflemesinin başarısının devam etmesi durumunda, bu uygulamanın enflasyonu az çıktı maliyetiyle önemli ölçüde düşürmek için bir fırsat olarak kullanılabilecek olmasıdır.