The Debate on Inflation Dynamics and the Swedish Experience

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Abstract

Inspired by the methodology of Galí and Gertler (1999) and Lindé (2005) and the seemingly fierce debate over the most appropriate econometric approach to study inflation dynamics, the new-Keynesian *hybrid* Phillips curve has been conducted with Swedish sample data and estimated with the general method of moment (GMM) and the full information maximum likelihood (FIML) estimators. GMM generated estimates that reject the idea of pure forward-looking behavior in price setting, but backwardness in price setting seems to be predominated. However, the generated results from GMM are somewhat conjectured in the sense that identification problem is apparent. Moreover the relationship between inflation and the so-called driving variable are not apparent. Due to this, a Granger-causality test between variables is employed. With identification in mind, the FIML yielded more significant estimates than GMM. FIML could not distinguish which price setting behavior is predominant to the same extent as the single equation estimator did. However, the estimated result seems to suggest that the majority of price setters have backward-looking behavior, indicating that backwardness in price setting has a relatively greater role. This is though the only aspect where the results in FIML are astray from the results in GMM, thus giving the impression that GMM is not obsolete. For instance, when it comes to the most relevant driving variable debate between marginal cost and output gap, the latter yielded estimates that has positive and correct sign. Indicating that output gap should also have an important role when studying Swedish inflation dynamics.

1. Introduction

In the past decade, the Phillips curve has had a renaissance in the sense that it has awakened a fierce debate over which econometric approach can adequately describe price setting behavior and inflation dynamics in general. An influential paper made by Galí and Gertler (1999) triggered this debate with a model called the new-Keynesian *hybrid* Phillips curve. From this, several papers have been made in the past with a vast variety of econometric approach. Intuitively, the different approaches fertilizes a debate where for instance one party supports the idea of predominance of forward-looking price setting behavior, while the other party emphasizes that backwardness in price setting is quantitatively important. One of the paper that support the latter, and thus rebuts Galí and Gertler's (1999) findings, are made by Lindé (2005) who also suggests that FIML is a better estimate than a single equation estimator.

With the debate in mind, Swedish inflation dynamics will be studied to see which party the yielded result supports. In section 2 of this paper, the important features of Swedish fiscal and monetary policy from a historic perspective will be briefly addressed. This is done while simultaneously explaining the evolution of the Phillips curve. An examination of the heated debate over the new Keynesian Phillips curve is presented in section 3. In section 4, the methodology of the paper alongside estimation and results will be presented, using the Swedish macroeconomic data that stretches from 1987 to 2012 on quarterly frequency. GMM and FIML estimators are employed in order to find inferences on Swedish inflation dynamics. Furthermore, Granger-causality test is established here in order to see the behavior of the relationship inflation and the so-called driving variable. Finally, in section 5, there will be some concluding remarks.

2. The Swedish experience and the tale of the Phillips curve

The relationship between inflation and unemployment was studied to some extent in the past, but it was not until 1958 that it received attention in the macroeconomic society. It was Alban Williams Phillips that came to the conclusion that there was a permanent negative trade-off between unemployment and inflation. The method of Alban William Phillips was quickly incorporated into macroeconomic models and theories. Therefore, the tradeoff between unemployment and inflation came under the name of the Phillips curve.[1] However, the theory has been challenged, altered and reestablished due to several global events, which in turn has affected many economic policies, including Swedish, throughout the decades. This section will take a brief look on the evolution of the Phillips curve and the Swedish reaction to it.

2.1 Broken tradeoff

During the 1970s, the industrialized countries were hit by volatile economic activities. The reasons for this were many, such as the fall of Bretton Woods and the oil crisis. These events affected the foundations of many conventional macroeconomic theories, including the Phillips curve. The fast appreciating inflation rate at a high unemployment rate during the 1960s and 1970s, made scholars raise some adequate questions surrounding the theory. The questions were derived from the broken tradeoff, as stagflation occurred for the vast majority of industrialized economies.[2] The questions that were raised towards the conventional Phillips curve was that the theory failed to take account of the changes in inflation expectations in the short run. The explanation for this can be traced to the relatively stable level of inflation expectations in the past. However, due to the stagflation, increase in the inflation expectations was severe in many countries.

Sweden experienced the broken tradeoff. The occurrence of the oil crisis in 1973 pushed the price of the commodity upwards and forced the economy into a steep stagflation, which threatened the economy into a forceful recession. The word *kostnadsexplosionen* (the cost explosion) was a common word that politicians used in order to describe the significance of

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[1] Sørensen and Whitta-Jacobsen (2005), p. 477
[2] Gordon (2009), p. 8

the unprecedented increase in prices. With this in mind and the self-evident stagnation of pivotal industries such as export, commodities and social service, both socialist and liberal politicians called for an all-out stimulus fiscal policy and structural reforms to stabilize employment through higher output in the major sectors and the economy in general.[3]

One can make the argument that the Swedish government implemented measures that undermined the advice of scholars, such as Friedman (1968) and Phelps (1967 and 1968). Friedman (1968) emphasized that the conventional theory, known as the *Keynesian* economics, lacked adequate explanations of the real wage. Instead, Friedman (1968) and Phelps (1967 and 1968) suggested that *Walrasian* microeconomic theories should be incorporated into the Phillips curve model. Furthermore, even though policymakers can determine the unemployment rate in the short-term, they should not determine its natural level with aggressive fiscal and/or monetary policy measures, as it can generate predicaments to the economy in the future. The theory of Friedman (1968) and Phelps (1967 and 1968) is known as the *expectations-augmented* Phillips curve, a sub-theory of the *neoclassical* economics.[4]

However, again, the Swedish government ignored the then modern views of the Phillips curve. The so-called *överbyggnadspolitiken* (the superstructure policy), were initiated by the socialist government in 1972 with the goal to stabilize employment and mitigate inflation. The government focused mainly on price regulations and direct subsidies to essential industries, such as the export market. This stimulus maneuver was supported by the opposition (the agrarians, the social liberals and the conservatives) and continued on when they controlled *Riksdagen* (the Swedish parliament). The consequences for the superstructure policy investment led to severe deficits on both the current account and the budget, which in turn led to an enlarged national debt.[5] Inflation increased to some extent on higher frequency compared to the increase in output, but most importantly, the unemployment rate increased slightly despite the superstructure policy.

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[3] Krantz and Schön (1983), p. 478
[4] Gordon (2009), p. 9
[5] Regeringskansliet (1999), p. 153

2.3 the Academic consensus and the Swedish battle against inflation

Co-inspirer to the expectations-augmented Phillips curve, Lucas (1972 and 1973) argued that agents rationalize price changes in relative terms and not in general terms, as the conventional theories seem to claim.[6] This argument goes in line with the theories of Friedman (1968) and Phelps (1967 and 1968). Lucas (1972 and 1973) emphasized that asymmetric information is more likely to occur in the markets, as agents misinterpret the general price changes in the economy. In the short-term, this will lead to a higher variance on inflation and a more positive co-movement with output. However, in the long-term, agents will rationally expect inflation and output to depreciate. More importantly, the unemployment rate changes are to some extent lethargic to the movements of inflation in the short-run, and therefore policymakers can only decide the unemployment rate in the long-term.[7] These assertions are called the Rational Expectations theory, and they derived the Real Business Cycle theory.

However, in the late 1970s, inflation was depreciating for many industrialized economies, where inflation seemed to have a one-year lead over unemployment rate, but the relationship was still positive. The notion that policymakers could only stabilize the economy in the long-term lost its hierarchy in the debate. From this, a great consensus between Keynesian and Walrasian economists was built, with a new collaboration called the *new-Keynesian economics*. Scholars concluded that short-term deviations of economic activities from its long-run equilibriums could occur.[8] However, new-Keynesian economists of the 1980s emphasized that economic activities were determined by nominal mechanism, such as sticky prices and sectorial shocks. This was a clear deviation from the Walrasian theory.[9] Microeconomic mechanisms were incorporated into the Keynesian version of the Phillips curve.[10] This modernization is known as the *consensus expectational natural-rate* Phillips curve.

In Sweden, the debate over inflation was very much at large. Due to the global economic recovery and the increasing demand for Swedish goods, the socialist government that took power in the election of 1982 had to combat inflation. An austerity measure known as

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[6] Lucas (1973), p. 327
[7] Ibid., p. 333
[8] Gordon (2009), p. 13
[9] Mankiw (1989), p. 87
[10] Laidler and Parkin (1975), p. 794

sparpropositionen (the savings bill) were implemented. Furthermore, the so-called *inflationsmålen* (the inflation target) of four percent were also implemented.[11] Also, two steep devaluations of the Swedish Krona took place in the early 1980s. Politicians believed that these measures, known as *novemberrevolutionen* (the November revolution), should keep the inflation level at bay. But, as mentioned before, the global economy was surging throughout the 1980s.[12] Instead, the November revolution fueled the important banking sector with cheap credit, especially in the real estate market.[13]

In the late 1980s, it was self-evident that the economy was overheated and that an economic bubble was created. Clearly, the Swedish government opted for the conventional Keynesian doctrine. Now, the government focused on microeconomic level to combat inflation and economic volatility. Mandatory savings system for the household and the business sector, alongside an overhaul of the tax system, known as the *århundradets skattereform* (the tax reform of the century), was put in place. These austerity implementations breached the socialists campaign promises, which led to a government crisis and a change of government. The new conservative-social liberal government that came into power in 1991 continued the prevalent austerity policy road in order to balance the national deficit.

2.4 The change of focus from fiscal policy to monetary policy in Sweden

In the global academic arena, the debate over how to correctly estimate agents' expectations on inflation continued. Scholars, such as Roberts (1995) and Galí and Gertler (1999), suggested that wage structure is a strong determent of the price dynamics in an economy.[14] Other factors, such as working efficiently versus shirking and technological evolution, came into the debate, where Shapiro and Stiglitz (1984) emphasized the importance of employers' behavior in the economy.[15] In other words, the evolution of the Phillips curve was mainly focused on wage and employment.

The debate on unemployment was the dominating factor in Sweden, as the austerity policies brought uncertainty into the markets and the economy in general. In fact, it drew the economy into its worst performance since the Second World War. The unemployment rate

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[11] Regeringskansliet (1999), p. 188
[12] Jakobsson (1997), p. 141
[13] Regeringskansliet (1999), p. 205
[14] Roberts (1997), p. 4
[15] Shapiro and Stiglitz (1984), p. 443

appreciated rapidly and forced the natural unemployment rate to levels that were unseen in the past.[16] This crisis initiated one of the greatest financial crises for the country up till date. It started in 1992, where all of the seven major banks in the country had credit problems. The government, alongside the opposition, granted a sweeping guarantee for the ailing banking system, where a special agency called *Bankstödsnämnden* (the Banking Support Agency) had the authority to mitigate moral hazard.[17] Moreover, the new socialist government that took power after the election in 1994, tightened fiscal policy with several regulatory changes. For instance, *rambeslutsmodellen* (the framework model) and a spending ceiling for the state budget were implemented.[18]

The financial crisis had an important role when it came to the currency crisis. During the autumn of 1992, the central bank of Sweden raised the interest rate dramatically in order to preserve the fixed exchange rate. However, due to the external speculative attack against the Swedish Krona, the appreciation of the interest rate measure was short-lived and the currency was let free to a floating exchange rate during the same autumn.[19] An inflation rate target of two percent per annum, with a deviation of one percent, was implemented.[20] Furthermore, in 1999, a new law of stronger independence for the central bank of Sweden was implemented. The strong regulations against enlarged fiscal spending, the central bank independency and the floating exchange rate made it possible for Swedish policymakers to use more monetary policy measures to deal with the mechanisms behind the Phillips curve. Indeed, monetary policies, with focus on real variables such as real exchange rates, are essential parts within the new-Keynesian doctrine.[21]

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[16] Konjunkturinstitutet (2011), p. 109
[17] Bäckström (1998), p. 11
[18] Jonung (2000), p. 28
[19]Ibid., (2000), p. 27
[20] Regeringskansliet (2013), p. 217
[21] Zamulin and Golovan (2007), p. 1

2.5 The Great Recession and the Return of the Phillips Curve

With the fiscal discipline and the independence of the central bank, Sweden joined the rest of the industrialized economies with economic growth throughout the mid 1990s to the end of the 2000s. For instance, government surpluses reached 3.8 and 2.5 percent of GDP in 2007 and 2008, respectively.[22] As the rest of the industrialized economies, inflation and unemployment were simultaneously low in Sweden. Abreast to the increasing globalization, where developing economies were roaring forward, the low inflation and unemployment rate made the macroeconomic society and policymakers suggest that the Phillips curve was obsolete.[23]

However, the global economic surge was severely interupted by the Great Recession. During the surge in the 1990s and the 2000s, structured financial products, such as collateralized debt obligations (CDOs), were used to create new markets and spread risk amongst investors. CDOs were used in the American mortgage market, making it easier for investors to get high returns for seemingly non-risky assets. Wall Street played an important role as they manufactured CDOs and sold them to the investors. The key for the market to be kept alive was for the American housing prices to keep appreciating. However, in 2007, the housing prices in the United States were depreciating, turning CDOs into toxic assets. Speculators scrutinized all banks that presumably had a large proportion of CDOs on their balance sheets. Indeed, prior to the crisis, there was little or no transparency into these markets. In 2008, Bear Sterns was the first on Wall Street to fall, but it was not until the fall of Lehman Brothers that the global finance was struck by a tidal wave of troubles.[24] Now with more knowledge and insight, scholars and financial institutes tend to incorporate CDOs into the Phillips curve.[25] Indeed, due to the Global Recession, many believe that the Phillips curve has made an *ugly* comeback.[26]

For Sweden, the global financial anxiety turned into a real economic crisis, where a recession occurred due to a lowering global demand for Swedish manufacturing goods. To combat the economic downturn, the policy rate of the Swedish central bank was lowered several times and dramatically. Government investments and deregulations on several

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[22] Calmfors (2010), p. 5
[23] Ball (2006), p. 5
[24] PBS Frontline (2012)
[25] Scheicher (2008), p. 25
[26] the Wall Street Journal (2013)

important sectors were implemented.[27] The strong fiscal and banking regulations that were set upon the banking system since the 1990s, helped to mitigate a contagion of toxic assets.[28] During the year 2000, mandatory balanced budgets were set upon municipal and regional governments.[29] Furthermore, a *överskottsmål* (surplus target) was implemented.[30] Other measures were necessary and implemented accordingly by the conservative-social liberal government that took power in 2006.[31]

3. The components of the new Keynesian *hybrid* Phillips curve

Even though there have been some new inputs on the theory of new-Keynesian Phillips curve during the past decade, this section will address the seemingly fierce debate that surrounds the theory. The debate is derived from Galí and Gertler's (1999) *hybrid* version of the new-Keynesian Phillips curve, where inflation dynamics has a key role in the ad hoc to the theory of *staggered contract* by Taylor (1980), but also the work of Calvo (1983). The estimation method, used by Galí and Gertler (1999), came under intense scrutiny from scholars such as Lindé (2005). Their main message of critique can be boiled down to the seemingly biased results that Galí and Gertler (1999) obtained from their estimation method. However, the latter fired back on their main critics, arguing in the paper made by Galí *et al.* (2005) that their estimation method is legitimized and proven to be robust.

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[27] Regeringskansliet (2009)
[28] Statistiska centralbyrån (2009), p. 20
[29] Finanspolitiska rådet (2013), p. 9
[30] Konjunkturinstitutet (2013), p. 45
[31] Regeringskansliet (2011)

3.1 Galí and Gertler's new-Keynesian *hybrid* Phillips curve

With the *ugly* resurrection of the Phillips curve, a new paradigm of the theory has been established with variety of estimation methods and elements. Using U.S. postwar data, Galí and Gertler (1999) created what will later on be known as the new-Keynesian *hybrid* Phillips curve, with backward- and forward-looking elements, estimated with generalized method of moments (GMM).[32] It is based on the assumption of rational expectations, where agents deal with future inflation in the following manner:

$$\pi_{t+1} = E_t \pi_{t+1} + \varepsilon_{t+1}$$

However, there are some empirical predicaments in using GMM, where the expectational error ε_{t+1} can be correlated with a set of instruments incorporated in a model. For this reason, an additional assumption is employed in the rational expectations approach, where the expectational error ε_{t+1} is uncorrelated with the set of instruments $\mathbf{z}_t$, thus giving the following orthogonal condition:

$$cov(\varepsilon_{t+1}, \mathbf{z}_t) = E[\varepsilon_{t+1}\mathbf{z}_t] = 0$$

Galí and Gertler (1999) used the orthogonal condition in order to develop the following methods and make it possible for a hybrid version of the Philips curve to incorporate inflation inertia as well as estimate the price adjustment structural parameter θ:

$$E_t\{(\theta\pi_t - (1-\theta)(1-\beta\theta)mc_t - \theta\beta\pi_{t+1})\mathbf{z}_t\} = 0 \tag{1}$$

the second alternative method is:

$$E_t\{(\pi_t - \theta^{-1}(1-\theta)(1-\beta\theta)mc_t - \beta\pi_{t+1})\mathbf{z}_t\} = 0 \tag{2}$$

where θ is the price adjustment and β is the subject discount factor. Furthermore, the inflation rate is determined by mc_t, the percent deviation of the firm's real marginal cost from

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[32] Lindé (2005), p. 1136

its steady state value, and $E_t\{\pi_{t+1}\}$, the expected inflation rate. Also, $\mathbf{z}_t$ is a vector of instruments. Galí and Gertler (1999) argue that these alternative methods solve the small sample normalization problem that characteristically arises when using GMM. However, the real contribution to the Phillips curve theory from Galí and Gertler (1999) is the notion of price-setting firms, where they are either backward- or forward-looking. The breed of price setters is determined by a fraction, where the fraction of forward-looking firms is $1 - \omega$. Thus defining the fraction ω as the degree of backwardness in price setting.[33] With this in mind, two alternative solutions that allows one to attain the orthogonal condition are established as follow:

$$E_t\{(\phi\pi_t - (1 - \omega)(1 - \theta)(1 - \beta\theta)mc_t - \theta\beta\pi_{t+1})\mathbf{z}_t\} = 0 \tag{3}$$

and the second alternative is:

$$E_t\{(\pi_t - (1 - \omega)(1 - \theta)(1 - \beta\theta)\phi^{-1}mc_t - \beta\theta\phi^{-1}\pi_{t+1})\mathbf{z}_t\} = 0 \tag{4}$$

The structural parameters β, θ and ω are incorporated in the following hybrid version:

$$\pi_t = \lambda mc_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} \tag{5}$$

where the overall slope coefficient of marginal cost $\lambda \equiv (1 - \omega)(1 - \theta)(1 - \beta\theta)\phi^{-1}$, the reduced form coefficient on lagged inflation $\gamma_b \equiv \omega\phi^{-1}$ and the reduced form coefficient on expected future inflation $\gamma_f \equiv \beta\theta\phi^{-1}$. Moreover, the parameter $\phi \equiv \theta + \omega[1 - \theta(1 - \beta)]$. From this, one can draw two special benchmark cases. The first one is that if $\omega = 0$, all firms are forward-looking, converging the model into the benchmark new Phillips curve. The second case is when the model is implied to take a hybrid version of the Phillips curve. This case arises from the assumption of unity, that is when $\beta = 1 \rightarrow \gamma_f + \gamma_b = 1$.[34]

As a proxy for real marginal cost, Galí and Gertler (1999) used the labor income share to create the following version of their hybrid Phillips curve:

[33] Galí and Gertler (2000), p. 11
[34] Ibid., p. 14

$$\pi_t = \lambda s_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} \tag{6}$$

which intuitively is derived from equation (5). Looking at equations (3) and (4), and dealing with (6), to overcome the mentioned empirical problems becomes as follow:

$$E_t\{(\phi\pi_t - (1-\omega)(1-\theta)(1-\beta\theta)s_t - \theta\beta\pi_{t+1})\mathbf{z}_t\} = 0 \tag{7}$$

and

$$E_t\{(\pi_t - (1-\omega)(1-\theta)(1-\beta\theta)\phi^{-1}s_t - \theta\beta\phi^{-1}\pi_{t+1})\mathbf{z}_t\} = 0 \tag{8}$$

With the same set of instruments incorporated in the $\mathbf{z}_t$ vector as in the previous estimation strategy, the structural parameters θ and β were estimated with the nonlinear instrumental variable (NLIV) estimator. Furthermore, two alternatives to the benchmark case were chosen to test for robustness of the model. The first is the unity case as in the previous estimation method, $\beta = 1$, while the second one is to use the nonfarm business GDP deflator as an alternative to the overall GDP deflator. Overall, the postwar U.S. dataset and the estimation method used by Galí and Gertler (1999) to find inferences from (6) gave satisfactory results and are consistent with the underlying theory. For instance, the estimation alternative (7) yielded a result for the θ parameter that can be interpreted as the prices are fixed for approximately five quarters on average. Not only is the result in line with survey evidence made by scholars such as Rotemberg and Woodford (1997a), it is also consistent with the findings of Sbordone (1998). Furthermore, when it comes to drawing inferences derived from the parameter of the degree of backwardness in price setting ω, using estimation alternative (7) yielded a value that implied that roughly a quarter of price setters are backward-looking, while estimation alternative (8) implied that half of price setters are backward-looking. Thus, leading to the rejection of the assumption of pure forward-looking model. However, Galí and Gertler (1999) argued that the importance of backwardness is questionable, as the coefficient for the forward-looking behavior γ_f in (6) yielded a notably larger value than the backward-looking behavior component γ_b. Therefore, it is convenient to assume that backward-looking behavior is not quantitatively important. It is also worth mentioning that similar results are

derived from the nonfarm business GDP deflator. Moreover, the coefficient for the proxy of marginal cost λ, the labor share, in equation (6) yielded a positive and significant value.[35]

3.3 Lindé's critique

Lindé (2005) decided to construct a macroeconomic model, which were inspired by Clarida *et al.* (1999), in order to study the behavior of the GMM estimator. The model is based on the same U.S. postwar data used in Galí and Gertler (1999) and with the means of a Monte Carlo simulation. Alongside GMM, the nonlinear least squares (NLS) estimator was used in order to study the behavior of single equation methods on inflation dynamics. But before using the simulated data, Lindé (2005) used the following model to draw some inferences on the *actual* data with the NLS estimator:

$$\pi_{t+1} = \frac{1}{\gamma_f}\pi_t - \frac{\gamma_b}{\gamma_f}\pi_{t-1} - \frac{\gamma}{\gamma_f}s_t + \eta_{t+1} \tag{11}$$

where η_{t+1} is orthogonal to the information set in period t. In other words, one can now use the NLS procedure on (11) in order to get consistent estimates of (6). Intuitively, a major concern for the NLS method is the situation when $\gamma_f = 0$. However, Lindé (2005) argued that this scenario is highly unlikely. Moving on, equation (11) can be redefined as follow:

$$\pi_t = \beta_1\pi_{t-1} + \beta_2\pi_{t-2} + \beta_3 s_{t-1} + \varepsilon_t \tag{12}$$

which resembles a standard backward-looking Phillips curve. Lindé (2005) points out the difference between equation (11) and (12). First of all, the new-Keynesian Phillips curve implies that $\frac{\gamma}{\gamma_f} = \beta_3 < 0$, while in the backward-looking version, the parameter should be in the opposite sign. According to the method used by Lindé (2005), both considered driving variables yielded a negative value for γ, which is in contrast to the findings of Galí and Gertler (1999). Overall, the NLS estimator in equation (11) did not support the underlying theory. Instead, it seems to support the traditional backward-looking Phillips curve theory. However, Lindé (2005) makes it clear that the γ_f estimate was significantly larger than γ_b, and

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[35] Galí and Gertler (2000), p. 16

therefore, one should raise some serious questions to NLS estimator's result of pure backward-looking Phillips curve.[36] Therefore, Lindé (2005) used simulated data to study both single equation methods behavior. Moreover, two cases of robustness check on the macroeconomic model were established. One where there will be no measurement errors in the model and another when the errors will take place. Lindé (2005) explicitly explained that some benchmark parameters were chosen and other parameters were set in order to get satisfactory values from the simulated data. The set values were mainly inspired from the work of Rudebusch (2002), as well as the work of Estrella and Fuhrer (2003) and Clarida *et al.* (2000).[37]

When it comes to estimation *without* measurement errors, the results found by Lindé (2005) suggests that both single equation methods gave satisfactory estimated value for the γ parameter when γ_b predominates γ_f. However, the GMM procedure seems to stumble when it comes to estimating correct values for the γ_f and γ_b parameters. The estimation approach is, like in the *actual* data estimation procedure, delivering biased values for the mentioned parameters. The GMM shortcoming is, again, derived from the small sample selection, but also when it comes to the inflation inertia characteristics within the macroeconomic model. The NLS procedure seems to produce an upward biased estimate for the γ_f parameter when a white noise term is involved, while in the same case, the GMM approach gives a downward biased estimate. When it comes to the inflation inertia case, GMM is stubbornly supporting a backward-looking version of the Phillips curve. The shortcomings of the NLS procedure, however, is derived from the difficulty in parameterizing equation (11) to generate a negative γ estimate, a high value for γ_f and a low value for γ_b. To be more precise, Lindé (2005) noted that, when estimating the actual data with the NLS approach, the generated high value for γ_f and low for γ_b did not synchronize with the generated estimates of the parameters at hand when using the simulated data.[38]

Therefore, to study the mentioned contradicting results, Lindé (2005) proceeds with the second robustness check where the macroeconomic model were estimated *with* measurement errors. The measurement errors can presumably be traced to the measurement methods in establishing some of the variables in the model at hand. For instance, the output gap is measured with the means of the Hodrick-Prescott (HP-) filter. Orphanidis (2000) makes the

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[36] Lindé (2005), p. 1138
[37] Ibid., p. 1139
[38] Ibid., p. 1140

point that this type of application methods for the output gap can generate substantial measurement errors in the model and in the real economy if the central bank acts towards the method.[39] Furthermore, Lindé (2005) emphasizes the potential time-varying bias that can be derived from both CPI- and GDP-deflators. This leads to the case where one should detect error terms for both output and inflation rate variables, $v_{y,t}$ and $v_{p,t}$ respectively. Lindé (2005) argues that one should set $var(v_{y,t}) = 0.10$ and $var(v_{p,t}) = 0.01$, where the variance for the measurement error in the output gap should be relatively larger due to its stronger empirical impact in the real economy. With this notion in place, the behavior of the central bank is an important aspect for the model, as it is assumed that the central bank are following the *observed* output gap y_t and inflation rate π_t, instead of the *true* variables y_t^* and π_t^*. With this assumption, the measurement errors are transmitted into the real economy. Lindé (2005) concludes that the measurement errors had only limited importance for the time series properties of the data. However, both single equation methods gave unsatisfactory results from the simulated data. The NLS approach produces sober estimates solely when the γ_f parameter is near unity. But as the parameter becomes smaller, the NLS produces severely biased and inconsistent estimates. When it comes to the GMM approach, the simulated data results are similar to the ones when the estimator was detected with the actual data. The only difference was the resulting amplified biasedness in the case when γ_f is high and γ_b is low. Furthermore, as in the estimation approach *without* measurement errors, the GMM biases became smaller contingent on an increase of the sample size.[40]

     With the single equation methods generating biased estimates from the simulated data, the full information maximum likelihood (FIML) method is used in order to see if it is a better approach to obtain satisfactory estimates of the parameters in the macroeconomic model. Lindé (2005) argues that this is the case since the FIML has the ability to distinguish between the forward- and backward-looking versions of the Phillips curve. This implies in both scenarios when the model is specified *with* and *without* measurement errors. However, even though this seems to be the only pitfall of the procedure, FIML seems to generate some biased estimates when γ_f or γ_b is low. But with this in mind, both GMM and NLS failed to distinguish between forward- and backward-looking specifications when γ_f or γ_b is low. Thus, again,

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[39] Orphanidis (2000), p. 8
[40] Lindé (2005), p. 1142

giving the impression that FIML is a better approach even in this scenario.[41] In general, the result from the FIML estimation approach supported the idea that the backward-looking concept has more or equal importance as the forward-looking specification in the hybrid version of the new-Keynesian Phillips curve. Thus challenging the inferences of Galí and Gertler (1999). However, this notion is not etched in stone. Lindé (2005) argues that the null hypothesis of *no forward-looking behavior in the Phillips curve* depends on the test. Using the Likelihood Ratio (LR-) test, as in Fuhrer (1997), the null hypothesis could not be rejected. While using the Wald-test, as Lindé (2005) opted for, the null was rejected and thus supporting the concept that forward-looking behavior has some relevance in the model.[42]

3.4 Galí and Gertler, alongside López-Salido, refutes the criticism

In response, Galí *et al.* (2005) adamantly refutes the arguments from their critiques, including Lindé (2005). Explicitly readdressing the idea and inferences of the Galí and Gertler (1999), Galí *et al.* (2005) argues that the γ_b coefficient is statistically greater than zero and thus rejecting the pure forward-looking version of the new-Keynesian Phillips curve, but not the hybrid version.[43] Moreover, the forward-looking component is predominant in the model.

When it comes to the criticism laid by Lindé (2005), Galí *et al.* (2005) emphasizes that the derogatory inferences are derived from a use of an inadequate estimator. NLS is unable to properly account for the error term ε_t that can be generated from (6). Lindé (2005) argues that the error term at hand is vital for the Monte Carlo simulation approach, but Galí *et al.* (2005) rebuts the use of it due to the amplified risk of the error term being correlated with the variables at the right hand side of (6). Instead, assuming that ε_t is i.i.d., Galí *et al.* (2005) suggested that NLIV is a relatively sufficient estimator and has the capacity to, unlike NLS, produce similar inferences as the GMM approach adopted in Galí and Gertler (1999). An important strength of the NLIV approach is that it generates positive and significant estimate for the γ parameter in (11) when using labor income share as the driving variable. Using the detrended output gap instead will only generate the inaccurate sign for the slope coefficient

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[41] Lindé (2005), p. 1144
[42] Ibid., p. 1147
[43] Galí, Gertler and López-Salido (2005), p. 3

and thus strictly contradicting inferences made by Lindé (2005) on the driving variable aspect.[44]

However, Lindé's (2005) main argument is the need to use the FIML estimator in oppose to the single equation estimators. Galí *et al.* (2005) did not recreate similar simulation method. Instead, tangible arguments against the approach were made, where it seems that the FIML procedure is heavily favored by the method at hand. Furthermore, Galí *et al.* (2005) strongly refutes the superiority of the FIML approach. This is the case since one needs to assume that the econometrician fully understands the mechanisms of the entire economy. Galí *et al.* (2005) argues that this assumption is unlikely.

The avoidance of such assumption is the reason why a single equation method, such as the GMM estimator, is adopted by Galí and Gertler (1999). Adding up to the condemnation of the criticism made by Lindé (2005), Galí *et al.* (2005) argues that the FIML approach underperforms when it comes to drawing econometric inferences on the *actual* U.S. postwar data. This is mainly due to that Lindé (2005) opted to use output gap, even though the variable is not theory-consistent. However, using the theory consistent variable marginal cost, Galí *et al.* (2005) makes the case that other scholars who used different maximum likelihood methods, including FIML, generally supports the inferences of Galí and Gertler (1999).[45]

4. Methodology, estimation and results

With the debate in mind, estimation and result for Swedish inflation dynamics will take place in this section estimated with GMM and FIML. The prior estimator will be utilized in order to see if the estimate can yield similar results as in Galí and Gertler (1999). A weakness from GMM is the notion of identification. Therefore, the Hansen J- and the Kleibergen-Paap tests for over- and underidentification, respectively, have been employed. Furthermore, the Granger-causality test is also utilized in order to see if there are valid relationship between inflation and the driving variable with Swedish data. Lindé (2005) were keen to make the case that FIML is relatively more adequate than single equation method estimators, such as GMM. A reason for this is the yielded identification problems from GMM. Therefore, the FIML approach will also take place in this paper in order to see if the estimator can give some

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[44] Galí, Gertler and López-Salido (2005), p. 9
[45] Ibid., p. 10

understanding to the inflation dynamics debate.

4.1 Data and Methodology

The data used in this paper over inflation dynamics in Sweden has a conventional quarterly frequency and has a time period from 1987Q1 to 2012Q4. The data are mostly gathered from Organisation for Economic Co-operation and Development (OECD), Federal Reserve Bank of St. Louis, Statistiska Centralbyrån (SCB) and Riksbanken (the central bank of Sweden). The estimated results and econometric inferences were powered by STATA 12 and Eviews 7.

To draw inferences on Swedish inflation dynamics, the following new-Keynesian hybrid Phillips curve is utilized in this paper;

$$\pi_t = \lambda x_t + \gamma_f E\{\pi_{t+1}\} + \gamma_b \pi_{t-1} \tag{13}$$

As previously explained, there is a heated debate over which driving variable x_t is theory consistent. The driving variable can be defined as either marginal cost mc or output gap Δy. Galí and Gertler (1999) used the labor income share, or the real unit labor cost, as a proxy for marginal cost, while the detrended log GDP through HP-filter is opted as the measure for output gap. In this paper, for robustness check, the consumer price index (CPI) π_{cpi} is used alongside the percentage change of GDP deflator π_{gdp} as measures of inflation. These variables will mainly determine if one can draw sufficient inferences with the sample data over Swedish economy, using similar Galí and Gertler's (1999) approach with GMM. However, there are some issues in using GMM, where the vector of instruments z_t can correlate with the expectational error ε_{t+1} yielded from the assertion of rational expectations. Therefore, using the same assumption as Galí and Gertler (1999), the following method is used in order to make sure that the orthogonal condition is intact, and that the structural parameters β, θ and ω can be estimated;

$$E_t\{(\pi_t - (1-\omega)(1-\theta)(1-\beta\theta)\phi^{-1}x_t - \theta\beta\phi^{-1}\pi_{t+1})z_t\} = 0 \tag{14}$$

Interesting aspects from the primitive parameters in (13) and the structural parameters in (14) can be drawn. According to Galí *et al.* (2005), the slope coefficient of the driving

variable λ is expected to take a negative, thus an incorrect, sign when detrended log GDP is used as the driving variable for the model, while the sign of the slope should be altered when the labor income share is utilized.[46] As seen in section 3.1, λ is decreasing in θ, if the prices are rigid in a longer term on average, inflation becomes less sensitive to the fluctuation in the current real marginal cost, or output gap. That is, prices are complete rigid if $\theta = 1$ and fully flexible if $\theta = 0$.[47] According to the theory, if the degree of backwardness in price setting $\omega = 0$, one should accept the notion of pure forward-looking Phillips curve. However, this extreme is only theoretical and thus one should expect that $\omega > 0$. According to Galí and Gertler (1999), forward-looking price setting should have the pivotal role in the hybrid model, thus leading to the notion that $\gamma_f > \gamma_b$. With this in mind, backward price setting should not be quantitatively important.[48] On the other hand, Lindé (2005) found that $\gamma_f < \gamma_b$, thus coming to the conclusion that backwardness in price setting should at least have the relevant aspect in the model.[49] Furthermore, one should expect near unity for the discount factor, where $\beta \approx 1$.

The set of instruments in this paper are inspired to those used in Galí and Gertler's (1999) work.[50] Four lags of the choice of driving variable, inflation rate, long-short interest rate, which in Sweden is the difference between the ten-year and two-year government bond, and the wage inflation. Since Galí and Gertler (1999) are using a large amount of instruments, the Hansen J-test for overidentification will be utilized. Accordingly, the null is that the model is identified, and thus the orthogonal condition is intact. Rejecting this notion will lead to some of the instruments in the model might be redundant. Furthermore, to make the case of identification even more robust, the Kleibergen-Paap test for underidentification is established. From equation (13), it follows that the primitive parameters are identified if the Jacobian of the moment condition is of full rank. Since the hybrid model has two endogenous variables, π_{t+1} and x_t, and one exogenous variable, π_{t-1}, the null of underidentification for (13) is that $rank(\Pi) \leq 1$. If the null is rejected, $rank(\Pi) = 2$.[51] That is the coefficient matrix Π must be two in order for the full rank condition to be satisfied.

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[46] Galí, Gertler and López-Salido, p. 10
[47] Sbordone (2002), p. 268
[48] Galí and Gertler (2000), p. 19
[49] Lindé (2005), p. 1148
[50] Galí and Gertler (2000), p. 10
[51] Kleibergen and Mavroeidis (2008), p. 4

Plausibly, further examination on the driving variable debate is necessary. Therefore, the Granger-causality test is established in order to see if the chosen driving variable is feasible to use when studying Swedish inflation dynamics. The lag length is determined by either Akaike information criterion (AIC) or the relatively parsimonious Bayesian information criterion (BIC). The hypothesis is that inflation does not Granger-cause the driving variable. If failing to reject the hypothesis, it is with almost certainty that it is difficult to find variable lags that can with veracity satisfy the notion of identified model.

Lindé (2005) argued that econometric barriers are more likely when using single equation methods such as GMM. However, an issue that can occur when using the FIML is that the assumption of normally distributed errors should be obliged. Therefore, the FIML estimator on (13) and (14) is employed with and without errors in order to see if the sample data used in this paper can verify the arguments stated by Lindé (2005).

4.2 Estimation with GMM

In order to find inferences on Swedish inflation dynamics through Galí and Gertler's (1999) approach, equation (14) is chosen to estimate the structural parameters β, θ and ω alongside the primitive parameters λ, γ_f and γ_b in (13) with GMM. The results are reported in Table 1 below, where the test for over- and underidentification is also reported:

Table 1: Estimates of the new Keynesian hybrid Phillips curve

	$\pi_{gdp} = f(mc)$	$\pi_{gdp} = f(\Delta y)$	$\pi_{cpi} = f(mc)$	$\pi_{cpi} = f(\Delta y)$
instruments	$\pi_{gdp\{t-1\|t-4\}}$	$\pi_{gdp\{t-1\|t-4\}}$	$\pi_{gdp\{t-1\|t-4\}}$	$\pi_{gdp\{t-1\|t-4\}}$
	$mc_{\{t-1\|t-4\}}$	$mc_{\{t-1\|t-4\}}$	$mc_{\{t-1\|t-4\}}$	$mc_{\{t-1\|t-4\}}$
	$\Delta y_{\{t-1\|t-4\}}$	$\Delta y_{\{t-1\|t-4\}}$	$\Delta y_{\{t-1\|t-4\}}$	$\Delta y_{\{t-1\|t-4\}}$
	$spread_{\{t-1\|t-4\}}$	$spread_{\{t-1\|t-4\}}$	$spread_{\{t-1\|t-4\}}$	$spread_{\{t-1\|t-4\}}$
	$wage_{\{t-1\|t-4\}}$	$wage_{\{t-1\|t-4\}}$	$wage_{\{t-1\|t-4\}}$	$wage_{\{t-1\|t-4\}}$
β	0.842*** (0.085)	0.931*** (0.090)	0.485*** (0.097)	0.632*** (0.077)
θ	0.758*** (0.078)	0.851*** (0.101)	0.831*** (0.040)	0.901*** (0.055)
ω	0.633*** (0.098)	0.725*** (0.119)	0.245*** (0.047)	0.269*** (0.063)
λ	0.066 (0.044)	0.020 (0.024)	0.104** (0.042)	0.039 (0.028)
γ_f	0.485*** (0.051)	0.517*** (0.040)	0.415*** (0.078)	0.527*** (0.059)
γ_b	0.481*** (0.045)	0.473*** (0.040)	0.252*** (0.040)	0.249*** (0.045)
J-stat	13.553 [0.758]	12.465 [0.822]	21.497 [0.255]	21.358 [0.262]
KP-test	14.390 [0.727]	12.140 [0.880]	17.306 [0.569]	16.565 [0.619]

Table 1 reports GMM estimates of the primitive parameters of equation (13) and structural parameters of (14). They are presented row-wise with the two main cases. GDP deflator π_{gdp} and CPI π_{cpi} are measures for inflation. Both driving variables, marginal cost mc and output gap, which again is the detrended log GDP yielded by Hodrick-Prescott filter, $\Delta y = y - \bar{y}$, are reported for each mentioned cases. The 1%, 5% and 10% significance levels are indicated by ***, ** and *, respectively. The parenthesis reports the standard deviation. Furthermore, the Hansen J- and the Kleibergen-Paap tests for over- and underidentification, alongside the probability value of the test reported in the bracket, are presented in order to see if the model is identified.

Bifurcating results are reported in Table 1 depending on which variable is chosen as proxy for inflation. The theory behind the new-Keynesian hybrid Phillips curve is that

forward-looking price setters should have the essential role for a country's inflation dynamics, but one should not reject a possibility that backward-looking behavior has a role too. Looking at Table 1, the degree of backwardness in price setting ω suggests that one should reject the notion of pure forward-looking behavior. However, the estimate at hand is astray from the findings of Galí and Gertler (1999), where a quarter to a half of price setters is backward-looking in that paper. Here, Table 1 indicates that more than half of price setters are backward-looking when using GDP deflator as the measure for inflation. This gives a presumption that CPI is the relatively more adequate variable for inflation since the estimated value for ω is reported to be a quarter of price setting behavior. Furthermore, the backward-looking specification is predominated when CPI is inflation, which is in line with the inferences of Galí and Gertler (1999).[52] Hallsten (2000) also supported the notion of non-quantitatively importance in backward price setting when using the hybrid model with Swedish data.[53] With this in mind, Holmberg (2006) made a similar conclusion that CPI generated more reasonable estimates with Swedish data than GDP deflator.[54] However, Galí and Gertler (1999) emphasized that a reasonable value for the subjected discount factor should be $\beta \approx 1$, and thus used the unity case $\beta = 1$ for the hybrid model in order to draw robustness inferences in that paper.[55] Even though the estimated values for β with either inflation variables are highly significant, CPI generated estimates that are not in line with the intuition of near unity for the subjected discount factor. Intuitively, this amplifies the concern for the ambiguous estimated results from Table 1.

However, when it comes to the degree of price stickiness θ, satisfactory and unambiguous results were found in Table 1. It is satisfactory in the sense that estimates of θ are in line with several studies that suggests on average five quarters of sluggishness in price movements. Here, θ is approximately 0.80 to 0.90, which corresponds to on average price regidity between five to eight quarters. Again, the estimated numbers for θ are in line with several studies on price rigidity, when using different econometric approaches with different sample data.[56] Galí *et al.*(2005) were adamant to make the case that marginal cost is the theory consistent variable and that detrended outpup gap generated estimates with incorrect

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[52] Galí and Gertler (1999), p. 16
[53] Hallsten (2000), p. 16
[54] Holmberg (2006), p. 10
[55] Galí and Gertler (2000), p. 10
[56] Ibid., p. 12

(negative) sign for the slope coefficient of the driving variable λ.[57] Conversely, the correct sign are estimated through the sample data regardless the choice of driving variable. Paloviita and Mayes (2008) found that despite using output gap as the driving variable, λ is positive in almost every selected country in their Euro area inflation dynamics study.[58] Since the economic structure in Sweden is more similar to the European structure compared to the one in United States, it is reasonable to draw the conclusion that detrended output gap should have a relevant role when studying inflation dynamics in Sweden.

When it comes to the notion of the orthogonal condition that are required in order to utilize GMM on the new-Keynesian hybrid Phillips curve model, the Hansen J-test indicates that all cases in Table 1 are not overidentified. However, the Kleibergen-Paap rank test in Table 1 indicates that all cases are underidentified, thus the selected instruments are insufficient. This issue needs to be attended. Therefore, in Table 2 below additional lags of the variables in the set of instruments have been established. In order to have as many lags as possible due to the reported underidentification problem in Table 1, the unparsimonious AIC will determine the number of lags in Table 2. Furthermore, the primitive parameters in (13) and the structural parameters in (14), alongside the tests for identification is reported in Table 2:

[57] Galí, Gertler and López-Salido (2005), p. 11
[58] Paloviita and Mayes (2008), p. 13

Table 2: Estimation with GMM

	$\pi_{gdp} = f(mc)$	$\pi_{gdp} = f(\Delta y)$	$\pi_{cpi} = f(mc)$	$\pi_{cpi} = f(\Delta y)$
instruments	$\pi_{gdp\{t-1|t-5\}}$	$\pi_{gdp\{t-1|t-5\}}$	$\pi_{gdp\{t-1|t-5\}}$	$\pi_{gdp\{t-1|t-5\}}$
	$mc_{\{t-1|t-2\}}$	$mc_{\{t-1|t-2\}}$	$mc_{\{t-1|t-2\}}$	$mc_{\{t-1|t-2\}}$
	$\Delta y_{\{t-1|t-4\}}$	$\Delta y_{\{t-1|t-4\}}$	$\Delta y_{\{t-1|t-4\}}$	$\Delta y_{\{t-1|t-4\}}$
	$spread_{\{t-1|t-2\}}$	$spread_{\{t-1|t-2\}}$	$spread_{\{t-1|t-2\}}$	$spread_{\{t-1|t-2\}}$
	$wage_{\{t-1|t-8\}}$	$wage_{\{t-1|t-8\}}$	$wage_{\{t-1|t-8\}}$	$wage_{\{t-1|t-8\}}$
β	0.944*** [0.059]	0.977*** [0.057]	0.496*** [0.095]	0.610*** [0.062]
θ	0.810*** [0.088]	0.887*** [0.120]	0.833*** [0.038]	0.842*** [0.040]
ω	0.511*** [0.092]	0.556*** [0.116]	0.207*** [0.045]	0.177*** [0.051]
λ	0.034 (0.034)	0.010 [0.022]	0.103** [0.041]	0.080*** [0.027]
γ_f	0.589*** (0.046)	0.606*** [0.041]	0.433*** [0.079]	0.535*** [0.055]
γ_b	0.394*** (0.045)	0.388*** [0.043]	0.217*** [0.041]	0.184*** [0.045]
J-test	9.840 [0.957]	0.909 [0.972]	21.881 [0.290]	22.054 [0.282]
KP-test	25.219 [0.193]	21.386 [0.375]	32.225 [0.041]	29.561 [0.077]

Table 2 reports GMM estimates of the primitive parameters of equation (6) and structural parameters of (8). They are presented row-wise with the two main cases. GDP deflator π_{gdp} and CPI π_{cpi} are measures for inflation. Both driving variables, marginal cost mc and output gap, which again is the detrended log GDP yielded by Hodrick-Prescott filter, $\Delta y = y - \bar{y}$, are reported for each mentioned cases. Depending on the Granger-causality test result in Table 2, different sets of instruments within the case models are presented, where the Akaike information criteria determines the lags of inflation and the driving variables, as well as for the long-short interest rate spread and the wage inflation. The 1%, 5% and 10% significance levels are indicated by ***, ** and *, respectively. The parenthesis reports the standard deviation. Furthermore, the Hansen J- and the Kleibergen-Paap tests for over- and underidentification, alongside the probability value of the test reported in the bracket, are presented in order to see if the model is identified.

Unfortunately, the results are not unambiguous with GMM for (13) and (14). The reported estimates for the degree of price stickiness θ in Table 2 indicates that prices are sticky for approximately eight quarters when GDP deflator is the measure for inflation, while CPI yielded results that indicates prices are sticky up to three to five quarters. Even though these results have a large discrepancy, they are still similar to many studies regarding price sluggishness. Looking at the degree of backwardness in price setting ω, Table 2 reports estimates that rejects the intuition of pure forward-looking behavior for all cases. However, unlike the reported estimates in Table 1, backward-looking behavior are roughly a fifth of price setters when CPI is inflation, while GDP deflator indicates that half of the price setters has a backward-looking behavior. This is very much in line with the findings of Galí and Gertler (1999). Unfortunately, when studying the case of predomination of price setting behavior, satisfactory inferences cannot be made when CPI is the measure of inflation. Indeed, forward-looking price setting is quantitatively important when either CPI or GDP deflator is utilized as inflation in the model, but the case that $\gamma_f + \gamma_b \approx 1$ is far from fulfilled when CPI has the role. GDP deflator as inflation did, however, report sufficient estimates and satisfactory results when it comes to cases $\gamma_f > \gamma_b$ and $\gamma_f + \gamma_b \approx 1$. Furthermore, despite adjusting the amount of variable lags in the set of instrument, drawing inferences with veracity are cumbersome due to the identification problem. The Hansen J-test indicates that the orthogonal condition is satisfied, while the rank condition is not satisfied when GDP deflator is the proxy for inflation. Thus, when CPI is the measure for inflation, the Kleibergen-Paap test is rejected and therefore the model is identified. However, the reported results indicate non-satisfactory estimates for the subject discount factor when CPI is the measure for inflation, where the unity assumption is not reached.

Notably, negative and incorrect sign for the slope coefficient of the driving variable λ is absent for all cases in Table 2, including when output gap is defined as the driving variable. These results are aberrant to the findings of Galí and Gertler (1999) and strengthens the notion that output gap should have an important role equally to the marginal cost when studying Swedish inflation dynamics. However, again, when GDP deflator is the measure for inflation, Table 2 indicated insignificant estimates for λ. In general, it is clear that GMM is yielding ambiguous estimates and therefore makes it difficult to draw feasible inferences on Swedish inflation dynamics.

4.3 Causality test between inflation and the driving variable

Since Table 1 and Table 2 reported estimates for the slope coefficient of the driving variable λ that are positive when output gap is defined as the driving variable, thus challenging Galí and Gertler's (1999) findings of negative sign for the coefficient at hand, and that the coefficient is mostly insignificant irrespective to the choice of driving variable, the following bivariate vector-autoregression (VAR) model are employed with the Granger-causality test, the hypothesis is that $\{\pi_t\}$ does not Granger-cause $\{x_t\}$:

$$\pi_t = \alpha_1 + \sum_{j=i}^{k} \kappa_{1i}\,\pi_{t-i} + \sum_{j=i}^{k} \varphi_{1i} x_{t-i} + u_{t1}$$

(15)

$$x_t = \alpha_2 + \sum_{j=i}^{k} \kappa_{2i}\,\pi_{t-i} + \sum_{j=i}^{k} \varphi_{2i} x_{t-i} + u_{t2}$$

If accepted, it can be difficult to identify the coefficient on lagged inflation in the hybrid model. With this in mind and that Table 1 and Table 2 reported underidentification problems using the hybrid model on Swedish data, it is then plausible that additional lags should be included in the instrument set.[59]

Before conducting the Granger-causality test, the Augmented Dickey-Fuller (ADF) test for non-stationarity is required in order to see if inflation π_t, which is either defined as the percentage change of the GDP deflator or the consumer price index, or the driving variable x_t, which is either marginal cost or output gap, have a unit root process. Looking solely at the standard level of five percent significance level, the mentioned variables are integrated of order zero, except for marginal cost, which was $I(1)$. Now, Table 3 reports the results from (15), where u_{t1} and u_{t2} are assumed to be uncorrelated. In order to determine the appropriate number of lags for the VAR model and mitigate the risk for serial correlation, AIC and BIC are used here:

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[59] Nason and Smith (2008), p. 535

Table 3: Granger-causality test

case		AIC pr [lags]	BIC pr [lags]	case		AIC pr [lags]	BIC pr [lags]
(1)	$\pi_{gdp} \nrightarrow mc$	0.055 [6]	0.149 [2]	(3)	$\pi_{cpi} \nrightarrow mc$	0.814 [4]	0.670 [1]
	$mc \nrightarrow \pi_{gdp}$	0.138 [6]	0.134 [2]		$mc \nrightarrow \pi_{cpi}$	0.065 [4]	0.922 [1]
(2)	$\pi_{gdp} \nrightarrow \Delta y$	0.082 [5]	0.444 [1]	(4)	$\pi_{cpi} \nrightarrow \Delta y$	0.106 [4]	0.106 [4]
	$\Delta y \nrightarrow \pi_{gdp}$	0.304 [5]	0.310 [1]		$\Delta y \nrightarrow \pi_{cpi}$	0.082 [4]	0.082 [4]

Table 3 reports the probability for the hypothesis that inflation does not Granger-cause the driving variable. GDP deflator π_{gdp} and CPI π_{cpi} are measures for inflation and both driving variables, marginal cost mc and output gap Δy, which again is the detrended log GDP yielded by Hodrick-Prescott filter, are reported for each mentioned cases. The mentioned variables are $I(0)$, except for marginal cost which took one differentiation in order to be stationary. The lag length in (15) are determined by Akaike and Bayesian information criteria, which is reported in the brackets.

Again, focusing on the five percent significance level, there are no cases that suggest a rejection of the notion that inflation does not Granger-cause the driving variable. Only case (1) when AIC determines the number of lags indicates a rejection of the null, but that is only for the one percent significance level. The results in Table 3 are troublesome in the sense that if inflation does not have any causal effect on the chosen driving variable, it can be difficult to find sufficiency in the instrument set in order to satisfy identification. Studying inflation dynamics for three large Western economies, Nason and Smith (2008) emphasized that when the hypothesis at hand is not rejected, it can be difficult to appoint number of variable lags with veracity in order to satisfy identification in the model.[60] Clearly and strategically, one should be wary when utilizing GMM when studying inflation dynamics for Sweden using the new-Keynesian hybrid Phillips curve model, due to the identification problem.

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[60] Nason and Smith (2008), p. 537

4.4 Estimation with FIML

With the apparent problems yielded from GMM, Lindé (2005) emphasized that FIML is a relatively more robust estimator.[61] Therefore, estimation values for (13) and (14) using FIML are reported in Table 4:

Table 4: Estimation with FIML

	$\pi_{gdp} = f(mc)$	$\pi_{gdp} = f(\Delta y)$	$\pi_{cpi} = f(mc)$	$\pi_{cpi} = f(\Delta y)$
β	0.802***	0.888***	0.328	0.432***
	(0.104)	(0.074)	(0.201)	(0.168)
θ	0.706***	0.718***	0.803***	0.885***
	(0.134)	(0.062)	(0.054)	(0.045)
ω	0.615***	0.616***	0.261	0.339*
	(0.149)	(0.147)	(0.171)	(0.206)
λ	0.103	0.080**	0.157**	0.068**
	(0.103)	(0.039)	(0.079)	(0.033)
γ_f	0.458***	0.496***	0.285*	0.363**
	(0.073)	(0.058)	(0.172)	(0.143)
γ_b	0.498***	0.480***	0.283*	0.322*
	(0.065)	(0.062)	(0.162)	(0.168)

Table 4 reports FIML estimates of the primitive parameters of equation (13) and structural parameters of (14). They are presented row-wise with the two main cases: GDP deflator π_{gdp} and CPI π_{cpi} are measures for inflation. Both driving variables, marginal cost mc and output gap Δy, which again is the detrended log GDP yielded by Hodrick-Prescott filter, are reported for each mentioned cases. The 1%, 5% and 10% significance levels are indicated by ***, ** and *, respectively.

When it comes to the notion of the relative importance of price setting behavior, Table 4 reports estimates of the degree of backwardness in price setting ω that rejects the notion of pure forward-looking Phillips curve. However, Table 4 does not report predominance of either forward- or backward-looking price setting behavior, as the estimated values are very similar. With the large fraction of backwardness in price setting when GDP deflator is inflation and the undistinguished results in price setting behavior in mind, it is plausible to make the inference that backward price setting is quantitatively important. Which can resemble the

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[61] Lindé (2005), p. 1144

findings of Lindé (2005), where backward-looking price setting behavior had at least a predominant role for FIML estimates.[62] However, utilizing CPI as inflation yielded estimated value for ω that are very much in line with the results that Galí and Gertler (1999) generated. Galí *et al.* (2005) adamantly criticized their critics, including Lindé (2005), and stated that several studies utilizing alternative econometric approaches with maximum likelihood procedure endured results that support predominance for forward-looking price setting.[63] However, again, it seems that FIML generated ambiguous results when it comes to which price setting behavior should have the pivotal role for in Swedish inflation dynamics.

The FIML estimates reported in Table 4 were in line with the reported GMM results in Table 1 and Table 2 that indicates price stickiness of around five quarters. However, the FIML approach is not entirely flawless as it reports seemingly ambiguous estimates for the notion that the subject discount factor should be near unity, $\beta \approx 1$. With GDP deflator as the measure for inflation, highly significant and satisfactory estimates for β are reached with both marginal cost and output gap as measure of inflation. While CPI generated estimates that fell short. This is unfortunately also the case when one should expect $\gamma_f + \gamma_b \approx 1$, but CPI as inflation yielded estimates that are far from this case. However, the FIML generates positive estimates for the slope coefficient of the driving variable λ in both cases when either output gap or marginal cost is used as the measure for inflation. Notably, more significant estimates were found with FIML. These results supports the idea that output gap should have a mandate when studying Swedish inflation dynamics.

Cautiously, the results in Table 4 are conjecture in the sense that FIML has a pitfall of normally distributed errors assumption. This is a highly questionable assumption when studying inflation dynamics. Lindé (2005) emphasized this problematic assumption, stating that the need for this assumption is absent when opting to use the single equation estimator.[64] Therefore, Table 5 will report estimated values for the primitive parameters in (13) and structural parameters in (14) when errors are non-normally distributed.

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[62] Lindé (2005), p. 1148
[63] Galí, Gertler and López-Salido (2005), p. 12
[64] Lind´(2005), p. 1145

Table 5: Estimation with FIML

	$\pi_{gdp} = f(mc)$	$\pi_{gdp} = f(\Delta y)$	$\pi_{cpi} = f(mc)$	$\pi_{cpi} = f(\Delta y)$
β	0.802***	0.888***	0.328***	0.432***
	(0.006)	(0.015)	(0.027)	(0.052)
θ	0.706***	0.718***	0.803***	0.885***
	(0.006)	(0.013)	(0.014)	(0.023)
ω	0.615***	0.616***	0.261***	0.339***
	(0.008)	(0.024)	(0.025)	(0.052)
λ	0.103***	0.080**	0.157***	0.068***
	(0.004)	(0.008)	(0.014)	(0.017)
γ_f	0.458***	0.496***	0.285***	0.363***
	(0.003)	(0.008)	(0.023)	(0.040)
γ_b	0.498***	0.480***	0.283***	0.322***
	(0.003)	(0.009)	(0.024)	(0.040)

Table 5 reports FIML estimates, with non-normal distributed errors, of the primitive parameters of equation (13) and structural parameters of (14). They are presented row-wise with the two main cases: GDP deflator π_{gdp} and CPI π_{cpi} are measures for inflation. Both driving variables, marginal cost mc and output gap Δy, which again is the detrended log GDP yielded by Hodrick-Prescott filter, are reported for each mentioned cases. The 1%, 5% and 10% significance levels are indicated by ***, ** and *, respectively.

Despite the absence of the assumption of normally distributed errors, Table 5 reports FIML estimates of (13) and (14) that are very similar to the yielded estimates in Table 4. The only difference here is that all estimates are now highly significant and that the standard errors are reduced. These inferences are similar to the findings in Lindé's (2005) paper, where there were no large discrepancies in the generated results for FIML when the normally distributed error assumption is regarded and neglected.

5. Conclusion

This paper utilized Swedish quarterly data, stretching from 1987Q1 to 2012Q4, to find understanding and stance towards the seemingly heated debate on the theory of new-Keynesian hybrid Phillips curve. Inspired by the debate, led by Galí and Gertler (1999) and Lindé (2005), the estimated results in this paper yielded results that gave bifurcating supports towards the debating parties.

It is apparent that the estimated results from the GMM estimator for the new-Keynesian hybrid Phillips curve in this paper are ambiguous, depending on which variable are employed for inflation or the so-called driving variable. Furthermore, the yielded results for the slope coefficient of the driving variable were seldom significant, raising the question if GMM can identify which driving variable should be employed to study Swedish inflation dynamics. However, the most troublesome issue that arises with GMM is the identification problem. According to the results in this paper, the model is suffering from underidentification for all cases. This unfortunate result was strengthened with the Granger-causality test that failed to reject the null of inflation does not Granger-cause the driving variable, which means that it can be difficult to identify the model. However, despite these wary results, GMM generated estimates that are in line with the findings of Galí and Gertler (1999) and other scholars that have studied Swedish inflation dynamics, such as Hallsten (2000) and Holmberg (2005). Their findings were that indeed the pure forward-looking price setting model is abolished, but that backward-looking price setting behavior is not quantitatively important.

FIML failed to distinguish the quantitatively importance of either forward- or backward-looking price setting behavior, as the values of the coefficients are very similar. FIML, like GMM, generated estimates for the degree of backwardness in price setting that are bifurcating to the debate. When employing GDP deflator as inflation, the value of the fraction is well above a half, indicating that the majority of price setters are backward minded. This can lead to an inference that resembles the arguments made by Lindé (2005). However, when CPI is the measure for inflation, the fraction is at a level that supports Galí and Gertler's (1999) findings. Despite this ambiguous results, FIML outperformed GMM when it comes to generating significant estimates. Especially when it comes to the slope coefficient, strengthening the argument that output gap should also have an important role when studying Swedish inflation dynamics since the slope is positive irrespective of the choice of driving variable. Furthermore, Lindé (2005) argued that the FIML is a better estimate to

employ in order to study inflation dynamics, this since it does not suffer from the issues that are attached to the GMM approach. One issue is the identification problem, which gives the impression that FIML is relatively trustworthy estimator when studying inflation dynamics. However, a problem that arises with the FIML is the assumption of normally distributed errors. Despite this issue, using the FIML and estimating the hybrid model with and without a noise, the generated results are astray from each other.

Obviously, it is difficult to take a stand towards which estimator is the most sufficient, and also which variable should be utilized as inflation or which driving variable is adequate. Holmberg (2005) made similar statement that it might be more difficult to employ the hybrid model and draw sufficient inferences on Swedish inflation dynamics. The solution to this is perhaps that one should decide an estimator, proxy for inflation and driving variable and from there be aberrant to the choice, but simultaneously be wary of the issues that surrounds the chosen econometric approach.

References

Ball, L. M. (2006), *Has Globalization changed inflation?*, National Bureau of Economic Research

Bäckström,U. (1998), *Finansiella kriser – svenska erfarenheter,* Sveriges Riksbank

Calmfors, L. (2010), *The Swedish fiscal policy council – Experiences and Lessons,* Finanspolitiskarådet and Stockholm University

Calvo, G. A., 1983, *Staggered prices in a utility-maximizing framework.* Journal of Monetary Economics, Vol. 12, No. 3, September, pp. 383-398

Clarida, R., Galí, J. and Gertler, M., 1999, *The science of monetary policy: a new Keynesian perspective.* Journal of Economic Literature, Vol. 37, December, pp. 1661-1707

Clarida, R., Galí, J. and Gertler, M., 2000, *Monetary policy rules and macroeconomic stability: evidence and some theory.* Quarterly Journal of Economics, Vol. 115, No. 1, February, pp. 147-180

Estrella, A., Fuhrer, J.C., 2003. *Monetary policy shifts and the stability of monetary policy models.* Review of Economics and Statistics, Vol. 85, No. 3, pp. 94-104

Finanspolitiska rådet (2013), *Svensk finanspolitik – Finanspolitiska rådets rapport 2013*

Friedman, M., 1968. *The role of monetary policy.* The American Economic Review, Vol. 58, No. 1, March, pp. 2-17

Fuhrer, J.C., 1997. *The (un)importance of forward-looking behavior in price specifications.* Journal of Money, Credit and Banking, Vol. 29, No. 3, pp. 338-350

Galí, J. and Gertler, M., 1998. *Inflation dynamics: a sructural econometric analysis.* Journal of Monetary Economics, Vol. 44, No. 2, pp. 195-222

Galí, J., Gertler, M and López-Salido, J. D., 2001. *European inflation dynamics.* European Economic Review, Vol. 45, 1237-1270

Gordon, R. J. (2009), *The history of the Phillips curve: consensus and bifurcation*, Northwestern University, NBER and CEPR

Hallsten, K. (2000), *An expectations-augmented Phillips curve in an open economy*, Sveriges Riksbank

Holmberg, K. (2006), *Derivation and estimation of new Keynesian Phillips curve in a small open economy*, Sveriges Riksbank

Jakobsson, U. (1997), *Den svenska devalveringscykeln,* Umeå University

Jonung, L. (2000), *Från guldmyntfot till inflationsmål – svensk stabiliseringspolitik under 20e seklet,* Handelshögskolan

Kleibergen, F. and Mavroeidis, S. (2008), *Weak instrument robust tests in GMM and the new Keynesian Phillips curve*, Brown University

Krantz, O. and Schön, L. (1983), *Den svenska krisen i långsiktigt perspektiv,* Lund University

Konjunkturinstitutet (2011), *Konjunkturinstitutets bedömning av jämviktsarbetslösheten*

Konjunkturinstitutet (2013), *Överskottsmålet för offentliga finanser*

Laidler, D. and Parkin, M. J., 1975. *Inflation: a survey.* Economic Journal 85, December, pp. 741-809

Lindé, J., 2005. *Estimating new-Keynesian Phillips curves: a full information maximum likelihood approach.* Journal of Monetary Economics, Vol. 52, pp. 1135-1149

Lucas, R. E., Jr., 1972. *Expectations and the neutrality of money.* Journal of Economics, Vol. 4, April, pp. 103-124

Lucas, R. E., Jr., 1973. *Some international evidence on output-inflation tradeoffs.* American Economic Review, Vol. 63, No. 3, June, pp. 326-34

Mankiw, N. G., 1989. *Real Business Cycles: a new Keynesian perspective.* Journal of Economic Perspectives, Vol. 3, No. 3, pp. 79-90

Nason, J. M. and Smith, G. W., 2008. *Identifying the new Keynesian Phillips curve*, Journal of Applied Econometrics, Vol. 23, pp. 525-551

Orphanidis (2000), *Activist stabilization policy and inflation: the Taylor rule in the 1970s*, Board of Governors of the Federal Reserve System

Paloviita, M and Mayes, D, (2008), *Asymmetry and inflation dynamics in different specifications of the Phillips curve for the Euro area*, Bank of Finland

PBS Frontline (2012), *Money, Power and Wall Street*, http://www.pbs.org/wgbh/pages/frontline/money-power-wall-street/, accessed on July 1, 2013.

Phelps, E. S., 1967. *Phillips curves, expectations of inflation and optimal unemployment over time.* Economica, Vol. 34, No. 135, August, pp. 254-281

Phelps, E. S., 1968. *Money-wage dynamics and labor-market equilibrium*, Journal of Political Economy, Vol. 76, No. 4 (2), July/August, pp. 678-711

Regeringskansliet (1999), *Om stabiliseringspolitiken som läroprocess*

Regeringskansliet (2009), *Statligt stöd behövs i finanskrisens spår*, http://www.regeringen.se/sb/d/11410/a/131134, accessed on July 3, 2013

Regeringskansliet (2011), *Finanskrisen 2008 – en sammanfattning av regeringens åtgärder*, http://www.regeringen.se/sb/d/15334/a/179329, accessed on June 28, 2013

Regeringskansliet (2013), *Finanspolitiska rådets rapport*

Roberts, J. M., 1995. *New Keynesian economics and the Phillips curve*, Journal of Money, Credit and Banking, Vol. 27, No. 4, November, pp. 975-984

Roberts, J. M. (1997), *The wage curve and the Phillips curve*, Board of Governors of the Federal Reserve System

Rotemberg, J. and Woodford, M. (1997a), *An optimization-based econometric framework for the evolution of monetary policy*, Massachusetts Institute of Technique and Princeton University

Rudebusch, G. D., 2002. *Assessing nominal income rules for monetary policy with model and data uncertainty*, the Economic Journal, Vol. 112, pp. 402-432

Sbordone, A., 2002, *Prices and unit labor costs: a new test of price stickiness*. Journal of Monetary Economics, Vol. 49, No. 2, pp. 265-292

Sbordone, A. (1998), *Prices and unit labor cost: testing models of pricing*, Stockholm University

Scheicher, M. (2008), *How has CDO market pricing changed during the turmoil? – evidence from CDS index tranches*, European Central Bank

Shapiro, C. and Stiglitz, J. E., 1984, *Equilibrium unemployment as a workers discipline device*, the American Economic Review, Vol. 74, No. 3, June, pp. 433-444

Statistiska centralbyrån (2009), *Sveriges ekonomi – statistisk perspektiv*

Statistiska centralbyrån (2013), *Export till våra 30 största handelspartner.* http://www.scb.se/Pages/TableAndChart___26637.aspx, accessed on June 19, 2013

Sveriges riksbank (2013), *Inflation, arbetslösheten och penningpolitiken.* http://www.riksbank.se/Documents/Rapporter/Ekonomiska_kommentarer/2013/rap_e k_kom_nr01_130305_sve.pdf, accessed on June 19, 2013

Sørensen, P.B. and Whitta-Jacobsen, H.J., 2005. *Introducing advanced macroeconomics – growth and business cycles* (second edition), MacGraw-Hill, Maidenhead

Taylor, J. B, 1980, *Aggregate dynamics and staggered contracts*, Journal of Political Economy, Vol. 88, No. 1, Feb, pp. 1-23

Wall Street Journal (2013), *Phillips curve makes ugly comeback*,
http://blogs.wsj.com/economics/2009/01/27/phillips-curve-makes-ugly-comeback/, accessed on July 9, 2013

Zamulin, O. and Golovan, S. (2007), *A real exchange rate based Phillips Curve*, New Economic School and Center for Economic and Financial Research