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**TO WHAT EXTENT DO SUPPLY SHOCKS
AFFECT INFLATION?**
A literature review

Faculty of Management and Business
Bachelor's thesis
May 2022

ABSTRACT

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Bachelor's thesis
Tampere University
Business and administration degree program: Economics
May 2022

This bachelor's thesis will discuss the extent to which supply shocks affect inflation. This thesis is carried out as a literature review and is thus done by reviewing empirical results from various pieces of literature from around the world, with most literature studying the relationship using American data. Primarily this is done using the theory of aggregate supply curves, the Phillips curve, and shifts in these curves to represent supply shocks and studying their effect on inflation.

The results of the literature review suggest that the effects of supply shocks on inflation are varying, and each piece of literature made their own additions or changes to the Phillips curve to depict the inflationary power of supply shocks more accurately. The inclusion of the sticky-price assumption, interaction between price-setters and inflation expectations were all substantial additions to the traditional model and were added across different pieces of literature.

With these additions, the literature reviewed has found that large (in magnitude) supply shocks disproportionately affect inflation. The literature reviewed also found that inflation expectations are 'shock-anchored', thus emphasizing the point that shocks only create short term fluctuations in inflation and inflation returns to natural rates in the long-run. Other literature also found that supply shocks hold inflationary power in the long-run only when inflation was expected to remain high after a shock, thus further emphasizing the importance of including inflation expectations in the Phillips curve, and the monetary policy in place (as it affects expectations).

With each new piece of literature reviewed, this thesis came to a more rounded conclusion of how supply shocks affect inflation using the theory of aggregate supply and the Phillips curve.

Keywords: supply shock, inflation, Phillips curve, aggregate supply, long-run inflation, short-run inflation, Phillips curve estimation

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1. INTRODUCTION

In this thesis, the question “to what extent do supply shocks affect inflation?” will be discussed in relations to literature ranging from the 1970’s to the 2010’s.

Before the first big supply shocks affected the global economy and inflation rates in the 1970’s (referring to the OPEC oil shocks), inflation was known and accepted to be a monetary phenomenon. In the short-run and the long-run, inflation was explained by inflation expectation and unemployment. Friedman’s 1967 Presidential Address outlines these views and has inspired 50 years of macroeconomic debate afterwards. In the decades to come, macroeconomists have come a long way from Friedman’s simple yet trailblazing conclusions. With his Presidential Address being one of the most cited Presidential Addresses ever, macroeconomists have used his conclusions as a strong baseline for future research. (Mankiw & Reis, 2018) In the following years big shocks to economies around the world took place (eg. the OPEC oil crisis) and brought macroeconomists to focus on the expansion of Friedman’s model, for example to include supply shocks in the Phillips curve and the forecasting of inflation (as reviewed later in this review) (Ball & Mazumder, 2011). As discussed in the next section, the development of this research is important to follow especially now, as the world is dealing with the aftermath of the COVID-19 pandemic and increasing political turmoil around Europe. After experiencing both labor demand and aggregate supply shocks globally repeatedly for over 2 years, it is important to consider the repercussions this may have on our inflation rates around the world, in the short-term and the long-term (Brinca;Duarte;& Faria-e-Castro, 2020).

After the introduction section, a short explanation on the background of this topic and its relevance today will be given. Especially in the economic and social turmoil the world has been living through in the last couple years, it is important to shed light on the relationship between supply shocks and inflation. In the third section, some main concepts, theory, and historical events that are important to

understand will be defined before examining the review of the literature. Here the assumptions and theory of the literature studied will also be reviewed. After this in the fourth section, empirical evidence from the different literature studied will be reviewed. This thesis takes about 10 different sources and uses their empirical analysis and comments to build an overview on how and to what extent supply shocks affect inflation. In this section the question will be explored by defining the key controversies in the past, how economists have revised information since then, and how real world shocks and economic crises have affected economists' views on the relationship between supply shocks and inflation. This section will examine how the sources differ from, as well as relate to each other. It will also examine the methodology used to come to their conclusions, the aspects of their research that they focused on and finally I review their results and how their results differ to or are similar to each other. These results and comparisons will then be used to examine the question, "to what extent do supply shocks affect inflation?". Finally in the last section, conclusions from the results will be drawn and the research question will be answered using all the literature studied in the section before this. The aim is to come to a well-rounded review of the literature and understand why and how the Phillips curve has adapted to answer the question "to what extent do supply shocks affect inflation?".

2. BACKGROUND

In early 2022, inflation and supply shocks are economic phenomena that are being discussed in all industries, sectors and economies. In the past 2 years as a result of the COVID-19 pandemic, society and the economy have become more and more accustomed to facing economic shocks, especially aggregate supply and demand shocks. As the COVID-19 pandemic forced societies, and even entire economies to go into lockdown, it created large shifts in the aggregate demand and supply curves. COVID-19 caused some sectors of the economy to specifically suffer (for example movie theaters), but the main disruptions to the economy stemmed from shocks to labor. Workers' willingness/ability to work at a given wage was severely disrupted by the pandemic, creating the shift in the aggregate supply curve, and employers' willingness to hire at a certain wage was also disrupted because of the changes in aggregate demand for goods, and the uncertainty remaining around the persistence of the pandemic. In many sectors, it is not clear whether the shocks they were facing were rooted from the supply or demand changes, because the features of the shocks are typically associated with both demand and supply. However, in the private sector, Brinca, et al. contribute the fall in employment coming from mostly supply shocks. (Brinca;Duarte;& Faria-e-Castro, 2020) It is for this reason and others that I wanted to study specifically the effect of supply shocks on inflation.

The last two years has seen a historically high amount of supply shocks, however as we begin to leave lockdowns and social distancing behind us, a new worry is gripping economists and everyday citizens as inflation is increasing at unprecedented rates. The timing of this rise in inflation happening especially in the United States and other major economies around the world is interesting. This prompted me to study the specific effects of supply shocks on inflation. While the Phillips curve has modeled the relationship for decades now, the developments and new findings related to this model are interesting and important for studying the relationship between the two. From historic occurrences of inflation, central banks and citizens know that increased inflation rates can even lead to

devastating cases of hyperinflation, which can have devastating effects on the currency and credibility of the Central Bank. (Friedman, 1968)

The literature has also taken the assumption that “exogenous relative price changes of intermediate commodities (crude oil, for example) can be regarded as aggregate supply shocks” (Mio, 2001, p. 86). This claim is further explored in section 3.2. Because of the recent Russian invasion of Ukraine in 2022, there has been a sharp rise in oil prices globally. This has also brought the importance and relevance of the topic of the relationship between supply shocks and inflation. As one can deduce, the exogenous relative price-changes resulting from the war in Ukraine can be seen as an aggregate supply shock, thus resulting in a shift in the Phillips curve. For this reason as well as COVID-19, it is interesting to study the relationship between inflation and supply shocks.

3. BACKGROUND THEORY

To be able to follow this thesis with ease, in this section there will be discussion about the background theory behind some of the discussed terms and topics in the thesis. Firstly, the Phillips curve and its origins will be reviewed. Secondly, the differences in assumptions between the literature reviewed will be discussed. Thirdly inflation inertia and inflation expectation will be reviewed in relations to the literature. Finally, the OPEC oil shocks of the 70's will be reviewed as well, as a motivator for the study of supply shocks.

3.1 THE PHILLIPS CURVE

The Phillips curve is an essential theory and tool to use in discussing the relationship between inflation, unemployment, and supply shocks. In most of the empirical literature reviewed, this theory was used to study the relationship between inflation and supply shocks. The Phillips curve is derived from the aggregate supply curve, and thus shifts in the Phillips curve reflect shifts in the aggregate supply curve. The equation for the aggregate supply curve is below: (Mankiw, 2010)

$$P = EP + (1/\alpha)(Y - \bar{Y})$$

With some modifications to this equation, the inclusion of exogenous events (supply shocks, v), the subtraction of last year's price level, and using Okun's law to change output to unemployment, we are able to come to the modern Phillip's curve being taught to undergraduate students. (Mankiw, 2010)

$$\pi = E\pi - \beta(u - u^n) + v$$

With the terms referring to starting from the left inflation, expected inflation, beta (parameter measuring the response of inflation to cyclical employment) times cyclical unemployment, and finally supply shock. The Phillips curve can be used to represent the same macroeconomic ideas present in the aggregate supply curve. The aggregate supply curve shows the relationship between output and price level (or change in it), while the Phillips curve shows how the relationship between unemployment and inflation behaves. While the Phillips curve also

includes the variable for supply shocks, this model proved to be much more relevant for the review of literature studying the relationship between inflation and supply shocks. (Mankiw, 2010)

As the behavior of the aggregate supply curve changes between the short and long-run, the effects of supply shocks on inflation in both time frames is interesting to study. In the long-run, prices are flexible, and the aggregate supply curve is vertical. In the short-run however, prices are sticky and the aggregate supply curve is upward sloping. (Mankiw, 2010)

3.2 DIFFERENCES IN ASSUMPTIONS

In this subsection, the differences in the assumptions taken in the reviewed literature will be discussed. It is important to remember that many sources have made different assumptions in their models which may have contributed to a difference in the results of their models.

One key assumption that is important to take into consideration is the assumptions surrounding price flexibility. Some sources look at both situations, where prices are totally flexible and where prices are completely rigid, and some sources only look at one situation. Traditional sources, (such as (Gordon, 1975)), use a model in which some prices, such as oil and food are flexible, while others are rigid. Ball and Mankiw put heavy emphasis on the relevance of sticky prices or menu costs in the analysis of supply shock and inflation. Their model allows for the flexibility of prices to be endogenous in the model and thus for it to change over time. In some periods it may be oil and food prices that are flexible, however in other periods it could be other things. (Ball & Mankiw, 1995, p. 191) "They argue that the classical dichotomy between relative and general price change only holds under full flexibility of prices." (Dewachter & Lustig, 1998, p. 2)

Assumptions on optimal prices are also assumed. Ball and Mankiw state that their model assumes optimal prices when the shocks hit, but go on to reveal that their data suggests this assumption was inessential for the model. They suggest further research use a dynamic model without this assumption. However, note that their model would not work with a dynamic model. (Ball & Mankiw, 1995) Dewachter and Lustig, while finding many points of differences to Ball and Mankiw's research, also assume optimal prices, and assume a static model.

(Dewachter & Lustig, 1998) As in the real world, it is unlikely that prices are optimal when shocks hit the economy, so it is important to use models that may be reflected in real life. An interesting assumption about supply shocks has also been made in many sources, lending from Bruno and Sach's research from 1985. This assumption states that "exogenous relative price changes of intermediate commodities (crude oil for example) can be regarded as aggregate supply shocks" (Mio, 2001, p. 86). Ball and Mankiw also take this as given in their research, and also remind that "fundamentally, supply shocks are changes in certain relative prices" (Ball & Mankiw, 1995, p. 161). Intermediate commodities, also known as intermediate goods, are goods that are sold between industries for resale or to make another product (Mankiw, 2010). These commodities are noted to have relatively high price elasticity and high volatility of supply. Unexpected exogenous changes (or changes outside of the theoretical framework) in the relative price of intermediate commodities, for example oil, is attributed to shocks to the aggregate supply. This is because the demand of these goods will only change when faced by a supply shock, for example if there is no oil left. (Mankiw, 2010)

3.3 INFLATION INERTIA AND INFLATION EXPECTATIONS

Inflation inertia has been defined in different ways in different sources of literature, and is used in some of the literature reviewed. The term inertia, originating from Greek, refers to the persistent growth of something. This would imply that inflation inertia means when inflation is persistent but also having a positive value. (Mankiw, 2010) It would imply the rate of change continuing at whichever non-zero value, and would thus differ from persistence of inflation, as the persistence of inflation can remain at;

$$\Delta\pi = 0,$$

While inflation inertia refers to where the situation when the change, continues and accelerates. However, in this thesis I will be going on the definition taken by Mio, and that what is described above. Mio has defined inflation inertia as "a broad concept containing inflation expectations" (Mio, 2001, p. 86). Mio models inflation inertia with a lagged term, in aims to predict inflation today as a function of inflation yesterday. In his model he finds that the results are highly statistically

significant (β_1 is close to 1), and shows that if one observes high inflation yesterday one predicts to see high inflation today, thus showing the importance of assuming adaptive expectations in the Phillips curve. (Mio, 2001)

However, different sources use differing ways of assuming expectations for inflation (if they were included). Different sources have used different assumptions of how consumers and agents in the economy expect price levels to change. Some sources have used the assumption of adaptive expectations (for example (Gordon & Hall, 1985), (Mio, 2001)), which is the assumption that real inflation depends on past inflation. However, others have used the assumption of rational expectations, or argued in favor of the use of rational expectations. Gordon and Hall argue in their research that their assumption of adaptive expectations does not accurately depict the real world, and criticizes their use of adaptive over rational expectations. Rational expectations means that agents expect inflation to change based on information available today and how it will affect the future. (Gordon & Hall, 1985) Ball and Mazumder also argue for rational expectations to an extent, as they argue for 'level anchored' expectations according to a known level of inflation (discussed more in section 4.2) (Ball & Mazumder, 2011). In the real world, it is important to note that actors do expect prices to change based on all the information that one has, thus rational expectations seem to be closer to reality, however it is important to realize that while information is a good in abundance, reliable information can be hard to find, and this research may be hard to do for an ordinary agent.

3.4 OPEC OIL SHOCKS OF THE 1970'S AND THE PHILLIPS CURVE

The United States faced significant shocks to its economy in the 70's, which inspired the inclusion of supply shocks to the Phillips curve (Mankiw, 2010). In this thesis the OPEC oil shocks of the 1970's will be discussed heavily, so it is good to familiarize ourselves with the context and situation.

Most notably, the oil embargo of 1973, in which OPEC countries (countries with control over most of the world's oil), put an embargo on exporting oil to the United States. This created a large supply shock as the United States was importing a large portion of the oil they used from OPEC countries. The oil embargo resulted

in rapid inflation of prices and unemployment in the United States. (Mankiw, 2010, p. 282)

The effects of the OPEC oil shocks have encouraged debate on the effects of supply shocks both in the short- and long-run. According to classical theory, inflation is a product of the money supply. The high level of inflation after the OPEC oil shocks has proved that the classical dichotomy does not stand.

The lessons learned from the OPEC oil shocks are ever more apparent in today's economy as the Russian invasion of Ukraine has prompted sanctions against Russia's oil industry, leading to increases in gas prices and inflation worldwide.

4. REVIEW OF THE EMPIRICAL LITERATURE

The review of the empirical literature studied covers many aspects of the topic, and in this section of the thesis, the sourced literature and their key findings will be reviewed and discussed. To begin with, the restrictions of the literature reviewed will be introduced. Next, in subsection 4.1, as most sources use the Phillips curve to study the relationship between inflation and supply shocks, the similarities and differences in the models and data that the different literature used will be compared. After this in subsection 4.2, the literature will be reviewed in relations to the terms inflation, inflation expectation and inflation inertia (or inflation persistence), results in relations to these terms will be reviewed. Finally, in subsection 4.3, the literature will be reviewed in relations to the short- and long-run effects of supply shocks on inflation. The findings and conclusions of the literature studied will be compared and contrasted, and the conclusions will be examined with the question “To what extent do supply shocks affect inflation?” in mind.

The empirical literature reviewed in this thesis has some clear restrictions and focuses. To begin with, the matter of how supply shocks affect inflation in the short- and long-run is reviewed from the empirical literature, however most literature discusses the inflationary power of supply shocks in the short-run. Inflation persistence is also discussed in the literature studied, and it ties well into the long-run effects of inflation, it was also included along with inflation inertia. It is important to note that the literature reviewed is not contained to one economy or country, but rather from around the world. The OPEC oil shocks of the 1970's and their effect on American inflation also inspired much of the literature studied, thus the American economy may receive more attention than others, most notably the analyses by Ball and Mankiw, Ball and Mazumbder, Gordon, et al. However, economies such as the Japanese economy have also been discussed (Mio, 2001). Some of the literature will also be discussing the term inflation expectation, and its effect on the relationship between supply shocks and inflation.

4.1 ESTIMATING THE PHILLIPS CURVE

Most of the empirical literature considered for this thesis studied the effects of supply shocks on inflation using estimations of the Phillips curve. However, the exact way they estimated and modeled the Phillips curve differs between literature, with the way that data has been handled, variables that have been added/excluded, etc.

The traditional way to estimate the Phillips curve is outlined by the work of many, including Gordon and Friedman (Gordon, 1975) (Friedman, 1968). When Phillips curves were first introduced, they did not include an explanatory variable for the supply shock. Later this has become normal to include supply shocks as an explanatory variable or to control for supply shocks in their model, using proxy variables that aim to account for the phenomenon of the supply shocks, without explicitly modeling the effects of the variable (like an explanatory variable). Friedman's simple Phillips curve looked like this:

$$\pi = \pi_t^e + \alpha(u - u^*)_t + \epsilon_t$$

With the explanatory variables being expected inflation, the difference between unemployment and the natural rate of unemployment and an error term (as one can see it does not contain the supply shock variable). (Friedman, 1968)

Since 1982, after the OPEC oil shocks, economists came to include the supply shock variable in the Phillips curve, or at least control for it. The high price levels of the 1970's specifically after the oil shocks inspired new research and thought into the relationship between supply shock, inflation and unemployment. (Ball & Mazumder, 2011) In most of the reviewed literature, either the supply shock was added as an explanatory variable or a proxy variable. Supply shocks are quite difficult to measure and statistically compare, which is why in many cases it may not be included as an explanatory variable. Controlling for the supply shock variable, by using a proxy variable or an explanatory variable is very important in producing an unbiased model of the Phillips curve (one where other variables show their effect on the dependent variable and do not include explanatory work for omitted variables, eg. supply shocks). Augmentations have been made to the Phillips curve in attempts to capture the true effect of supply shocks on inflation, and it is noted that "identifying the exact channels through which supply shocks affect inflation turns out to be surprisingly hard" (Dewachter & Lustig, 1998, p. 2).

Additionally, the reviewed literature uses two alternative data sources: the CPI (Consumer Price Index) and PPI (Producer Price Index). Most infamously, these indices are known to measure inflation however, have different emphases. The CPI shows inflation from the perspective of consumers, and thus includes consumer goods which include imports, and taxes. The PPI shows inflation from the perspective of producers, and the industry, and thus doesn't include things such as imports or taxes, but includes sales. Using CPI data aims to adjust income and expenditure streams to show changes in the costs of living for consumers, while PPI aims to deflate revenue streams in order to measure real growth in output. Thus, we can see the change in perspective from consumer to producer. (U.S. Bureau of Labor Statistics, 2014) Of these indices, CPI is more commonly used. The use of CPI data was supported by many researchers such as Sommer and Mio. Ball and Mankiw on the other hand, use Producer Price Index data to examine the distribution of price change. (Ball & Mankiw, 1995, p. 163) Mio's estimation differed as he used the trimmed mean CPI data in order to calculate the asymmetry (the skewness) of the price change distribution (Mio, 2001). Mio argues for using the trimmed mean CPI data as changes in the trimmed CPI are smaller than changes in the headline CPI, as the tails of the distribution are given 0 weight and the rest of the data is averaged. The difference between the trimmed CPI and the headline CPI show the level of skewness in the price distribution. (Mio, 2001) The skewness is higher when divergence between the two is larger, and as Ball and Mankiw show in section 4.3, this (skewness) affects the way that shocks affect the inflation rate.

To illustrate the developments made in the years after Friedman's model, below is Mio's estimation of the Phillips curve: (Mio, 2001)

$$\pi_t = \alpha + \sum_{i=1}^l \beta_i \pi_{t-i} + \sum_{j=1}^m \gamma_j GAP_{t-j} + \sum_{k=0}^n \theta_k SupSHOCK_{t-k} + \varepsilon_t$$

As one can see the dependent variable is the inflation at time t . The first term on the right is a constant variable, the second term is lagged inflation (which is treated as a proxy for inflation inertia, see section 3.2), the third term is the output gap (difference between potential output and real output), the fourth term is the proxy for the supply shock and finally the fifth term is the error term. As one can

see Mio specifically added the proxy for inflation inertia when controlling the supply shock in his estimation of the Phillips curve. Mio models inflation inertia with a lagged term, with the aim to try to predict inflation today (as the dependent variable) as a function of past inflation. Thus, trying to make the case that past inflation (inflation in time $t-1$) has a substantial effect on the Phillips curve and real inflation in time t . (Mio, 2001)

If one compares this to the traditional Phillips curve, or the non-augmented Phillips curve, one can see some quite large differences between many of the sources (including Mio's model seen above) and the non-augmented curve. Below the Phillips curve that is taught to undergraduate students today is given: (Mankiw, 2010)

$$\pi = E\pi - \beta(u - u^n) + v$$

As one can see this model is much more simplified than many of the other estimations and augmentations of the Phillips curve used in the reviewed literature.

4.2 INFLATION INERTIA AND EXPECTED INFLATION

The literature studied has different stances on the terms inflation, inflation inertia and expected inflation. Some sources don't deal with the terms expected inflation and inflation inertia at all, and only discuss real or nominal inflation. However, especially in later literature, and when the literature discusses monetary policy thoroughly as well, there is more of a focus on these terms.

Sommer discusses inflation expectation and its importance in especially the effect of supply shocks on inflation in the long run. Sommer finds that during the period of Volker disinflation (1979-1982), the persistence of supply shocks in the U.S. inflation dropped significantly. His empirical results suggest that the difference between pre- and post-Volker periods lies in the change of the behavior of inflation expectations between these two periods. The data shows that mediators had different expectations about the continuation of shocks in these periods. They expected shocks to continue in the pre-Volcker period but not in the post-Volcker period. Sommer continues to study how the monetary policies put in place lead to different equilibria for the persistence of supply

shocks, and constructs a model for this equilibria. (Sommer, 2002) Mio on the other hand discussed both inflation expectations and inflation inertia. Inflation inertia has differing exact definitions, however in Mio's paper he defines inflation inertia as; "a broad concept containing inflation expectations" (Mio, 2001, p. 86). A more in depth look into the term can be found for this in section 2.2 of this thesis. Mio models the Phillips curve to include both inflation and lagged inflation to explain how the two affect each other while controlling the model with supply shocks. (Mio, 2001)

Mio comes to the conclusion that his model, including the proxy for inflation inertia, outperforms the traditional models of the past. He finds a strong correlation between inflation and lagged inflation when controlling supply shock effects for both inflation and lagged inflation. Thus, emphasizing the importance of inflation expectations (in his model finding adaptive expectations to be closer to the truth) and the persistence and power of inertia in inflation. (Mio, 2001, p. 95) If firms and consumers observe high prices yesterday, they predict to see high prices today, and thus change their behavior. Commonly this change in behavior can easily worsen the speed at which inflation increases, and this has been seen on many occasions as consumers may panic-buy products leading to a shortage of goods that then naturally increases the prices of the goods. This then can create a cycle of rising inflation, and keeps up the persistence of inflation. Thus, returning to the ideas and findings that Sommer made in his research, emphasizing the importance of inflation expectations especially when considering the persistence of inflation and supply shocks.

On the other hand, Ball and Mazumder also look at inflation expectations in their research and find that inflation expectations have been 'shock-anchored' since the 1980's. This thus differs from the heavy emphasis placed on adaptive expectations by Mio. (Ball & Mazumder, 2011) They find that since the 1980's supply shocks do not have as much inflationary power, as people expect the Central Bank to adjust monetary policy to bring inflation back to prior levels. This idea of anchored expectations is discussed more in section 4.3.

There may be reasons that some do not take inflation expectation into account in their research. Gordon and Hall go on to explain that there are different ways to interpret the lagged inflation term modeled in the Phillips curve. It can be treated

as a proxy for price expectations (assuming expectations are formed adaptively). This is a widely used interpretation and is even called ‘expectations- augmented Phillips curve’, when “equations explaining wage or price change in which one or more lagged price variables appear” (Gordon & Hall, 1985, p. 272). This quote thus further emphasizing the wide-spread use of lagged variables and inclusion of expectations (mostly assumed to have formed adaptively). However, Gordon and Hall note that the assumption of adaptive expectations is not rational, and thus this model is open to criticism. Rational agents should and would use all information at their disposal to form expectations about inflation. Gordon and Hall use this as an explanation for why they prefer the interpretation in which the lagged inflation term represents the inertia of wage- and price-setting institutions. They explain that this way he creates a mechanical relationship between current and past inflation, instead of making any assumptions in how the expectations are formed.

While Ball and Mankiw do not take inflation expectation into account in their model (Ball & Mankiw, 1995), Dewachter and Lustig use their model and add inflation expectations to their model by extending their model to include interaction among price-setters. Dewachter and Lustig conclude that the inclusion of inflation expectation results in their model outperforming the Ball and Mankiw model. (Dewachter & Lustig, 1998)

4.3 SHORT- AND LONG-RUN EFFECTS

The extent to which supply shocks can affect inflation can be examined in two regards, the long- and short-run. In this section, the effects of supply shocks on inflation will be discussed in relation to the short- and long-run.

Ball and Mankiw specifically discuss the short-term effects of supply shocks on inflation in their research. They study the shifts in the short-run Phillips curve based on changes in relative-prices and stickiness in nominal prices. Ball and Mankiw find in their research that their proposed method outperforms the traditional estimation of the Phillips curve (eg. Gordon method). (Ball & Mankiw, 1995)

They find that aggregate inflation depends on the distribution of relative-price changes in their research. Their model implies that changes in the price level are

positively correlated to skewness of relative prices in both the pre- and post-OPEC era. They explain that in past literature, more focus has been placed on the relationship between inflation and variability of prices, instead of inflation and skewness of relative prices. They lay the groundwork for their emphasis on how supply shocks affect inflation with different magnitudes, based on the skewness of the relative-price change distribution. (Ball & Mankiw, 1995) Ultimately, they use these findings to conclude that “when menu costs create a range of inaction in response to shocks, the distribution of relative-price changes influences the overall price level”. (Ball & Mankiw, 1995, p. 191) Intuitively with the conclusions of this model, it can be seen that if a negative supply shock was to hit an economy, that would mean that the distribution of desired price changes is skewed to the right. In the sticky-price model, firms will adjust their prices only if the price-change is greater than the potential menu costs (Ball & Mankiw, 1995). Positive skewness of desired price change thus means that large positive price changes are more likely to occur than large negative price changes. Thus, the results of the relative price increases outweigh the results of the relative price decreases on the general price level. And thus, the inflation rate increases. The results of Ball and Mankiw’s model outperform traditional models, and bring light to a whole new aspect. Large shocks affect the price level disproportionately more than small ones, with greater magnitude. (Ball & Mankiw, 1995)

Therefore, one can say that supply shocks affect inflation in the short-run to the extent that supply shocks have inflationary power, but their inflationary power differs in magnitude. Larger supply shocks have a disproportionate effect on the price levels, as Ball and Mankiw state with the inclusion of sticky prices. However, it is important to remember the assumptions made in Ball and Mankiw’s research, for example the assumption of optimal prices. In the case of most supply shocks, prices are not optimal before they come into effect. Ball and Mankiw suggest future research take this into account.

Ball and Mankiw’s paper is thoroughly reviewed and generally respected by academic peers, however there are economists that point out flaws in their model. Dewachter and Lustig extend Ball and Mankiw’s model to include interactions among price-setters, thus also bringing into play inflation expectations and the assumption of rational expectations. Ball and Mankiw do not discuss inflation

expectations in their model. Dewachter and Lustig argue that when agents expect inflation to occur because of supply shocks, they will raise their prices by even more if they are in the upper tail of the desired price change distribution. Furthermore, in the lower tail of the distribution, firms will lower their prices by less. This creates an even larger increase in the general price level. (Dewachter & Lustig, 1998) Similarly, Dewachter and Lustig find correlation between inflation and skewness of industry price changes. However, they find that with their model, the model yields more accurate results. Thus, resulting in their conclusion that the inclusion of inflation expectation is essential in the study of the inflationary power of supply shocks. (Dewachter & Lustig, 1998). Dewachter and Lustig argue that Ball and Mankiw's model is not capable of producing enough inflation to "qualify as a valuable theory of short-run inflation" (Dewachter & Lustig, 1998, p. 4). They argue that Ball and Mankiw's model results in supply shocks having quite low inflationary power. The inflationary effects of supply shocks in the no-interaction case (Ball and Mankiw's case) are quite small. They argue that their model including inflation expectation and interaction among price-setters provides a more valuable theory of short-run inflation. (Ball & Mankiw, 1995) It's also important to remember that in reality, firms and price-setters use expectations about the future to make decisions about their prices. Intuitively, ignoring this interaction between price-setters is not a depiction of the real world's economy, however Ball and Mankiw's analysis brought a new dimension to the analysis of the relationship between supply shocks and inflation.

Consequently, one can argue that inflation expectations affect how largely supply shocks affect inflation. Inflation expectations are important to include as they affect the inflationary power of supply shocks. One can also argue that many of Ball and Mankiw's findings were relevant, including the focus on stickiness of prices and the relationship between aggregate inflation and skewness of prices versus the traditional inflation and variance of relative-price change relationship.

Building upon the importance of using inflation expectation when considering the effects of supply shocks on inflation, more recent literature brings the term 'anchored expectations' to the discussion. Ball and Mazumder examine this term as the expected inflation dynamics were puzzling when using them to predict inflation during and after the Global Financial Crisis (2008-2010). In Ball and

Mazumder's research they define two terms, 'shock anchoring' and 'level anchoring'. They define shock-anchoring as a term meaning that shocks to inflation are not permanent, and are not passed into expectations nor future inflation. Level anchoring, meaning that "expectations are tied to a particular level of inflation" (Ball & Mazumder, 2011, p. 19). They find that since the 1980's, (after Paul Volcker's monetary regime), the Fed has committed to stable inflation, and agents in the economy know this, which has resulted in supply shocks not strongly affecting expectations or future inflation. (Ball & Mazumder, 2011) The difference between the pre-Volcker and post-Volcker era has also been studied by for example Sommer (2002) as discussed prior. These findings are supported by Sommer (2002) and Hooker (2002), and thus brings us to the idea that expectations have become shock-anchored. However, Ball and Mazumder also argue for the idea of level anchoring more recently. They find that shock anchoring has been a phenomenon since the 1980's, however the idea that inflation should be kept at a specified level (2 %) has first been discussed in Central Banks in the early 90's. (Ball & Mazumder, 2011) They argue that in the future, this level anchoring may hold more truth than shock anchoring. Hooker argues that it may be that monetary policy has changed since the Volcker regime, and hasn't become less accommodative of supply shocks, but has "helped to create a regime where inflation is less sensitive to price shocks more generally" (Hooker, 2002, p. 540)

Thus, one can argue that supply shocks in the modern economy may not have as large of an effect as past papers may have argued. Stable monetary policies around the world may have created this 'shock anchoring' situation where agents in the economy trust and expect that inflation will return to natural rates after a shock. However, this is interesting to consider in economies in which trust in the monetary policy of the central bank may not be as high. In economies like these it can be suspected that this expectations anchoring may not hold. However, even if this doesn't explain the inflation dynamics of all economies it is still valuable to consider as it shows the importance of inflation expectations. Intuitively, if the supply shock affects inflation expectations or their behavior, it quite surely will affect real inflation as well. However, this shock anchoring is interesting to consider in situations where inflation persists longer than agents are used to.

While generally even if the Central Bank is trusted in an economy, for example in the United States (as discussed by Ball and Mazumder), it is important to remember that political climates have changed very much since their findings in 2011. Extremism and polarization have increased distrust in institutions. Additionally fear mongering has become easier with the widespread use of the internet and social media, which can increase distrust in institutions including the Central Bank. This varying trust may weaken the strength of the argument by Ball and Mazumder introducing the shock anchoring term.

There has also been much discussion about the effect of supply shocks in the long-run. Many pieces of literature study the long-term effects by studying the persistence of inflation. When discussing the long-term effects of supply shocks on inflation, the intuitive explanation is mostly taken from the effects of the Great Inflation of the 1970's. However, there are different views on this as well. One explanation is that under accommodative monetary policy, supply shocks feed into inflation expectations, instead of inflation directly. Inflation will remain high until the Central Bank tightens their policy which will drive the economy into a recession. An alternative view is the opposite, supply shocks only affect short-term inflation and do not affect inflation in the long run. (Sommer, 2002) Sommer finds interesting and differing results for different time periods. Sommer finds that in the period prior to Volcker's disinflation (1960-79), supply shocks had a long-run effect on the inflation rates. He finds that the magnitude of the long-term effect is about half of the size of the initial effect. He notes that the effect of supply shocks on inflation diminishes in less than 6 months after the Volcker monetary regime. (Sommer, 2002) Since the 1980's, other research has also shown that supply shocks have not fed strongly into future inflation. (Hooker, 2002) Sommer finds that the persistence of inflation (or the shocks on inflation) are closely linked with the expectations of agents related to the permanence of shocks. During this studied period Sommer found that agents expected the shocks to inflation to be permanent, thus further feeding into the inflation expectations and continuing the persistence of inflation. However, when agents believe that the shocks and their effects are temporary, price levels return to their initial levels. (Gordon, 1984, pp. 41-42) Sommer goes on to review the period of the Great Inflation, and how explanatory supply shocks were in the increase of inflation over these years. He

compares his results to those from the past, which accounted supply shocks playing a small role in the run-up of inflation during this time, and claimed that the main causes lied in fiscal and monetary policies that were expansionary. He supports this view and finds that supply shocks had a permanent effect on inflation, however did not explain most of the observed changes in inflation.

Thus, it can be said that supply shocks affect inflation to the extent that shocks to markets can have a permanent effect on prices and the inflation rate of the future depending on the monetary policy being conducted. While agents expect shocks to persist, they keep expectations high, which further feeds into real inflation and vice versa.

While some research makes a strong case for the effects of supply shocks on inflation. Further research (as discussed prior), for example Ball and Mazumder, have also argued that supply shocks do not have as much inflationary power as assumed. According to classical theory, money supply determines the price level, and thus the rate of inflation. As famously argued by Milton Friedman, "Inflation is always and everywhere a monetary phenomenon". (Friedman, 1968, p. 39) This can be partly true and false, as seen above, supply shocks have inflationary power, but often this may be because supply shocks can cause changes to monetary policy, which then causes a change in the inflation rate. However, shifts in the money supply are not exclusively responsible for inflationary changes. It is commonly explained that under periods of inflation instability, and while the Central Bank is under accommodative monetary policy, supply shocks only feed into inflation expectations and not directly to real inflation. Inflation will remain high until the Central Bank tightens their monetary policy and drives the economy into a recession. (Sommer, 2002) Arguing that inflation is a result of monetary policy and not of shocks. Ball and Mazumder's findings also emphasize how inflation expectations are very significant in determining future inflation, and that expectations have been 'shock-anchored'. Sommer's research argues for the importance of monetary policy in the persistence of inflation, thus showing that with differing monetary policy the long-term effects of supply shocks on inflation can be different, while Ball and Mazumder's model argues that shocks do not have inflationary power.

However, Ball and Mankiw note that the inclusion of the supply shock variable in the Phillips curve is important and needed, and this has been the consensus among most macroeconomists since the OPEC oil crisis. Gordon also argues that it is very important to recognize that inflation depends on shifts in not only supply (cost-push inflation) but also demand (demand-pull inflation). (Gordon, 1984)

5. CONCLUSION

To conclude this thesis, there has been differing conclusions on the relationship between supply shocks and inflation. As time passes, macroeconomists have argued for the addition and exclusion of different things to the Phillips curve in order to find more accurate results. Focuses have also shifted between many aspects.

According to Ball and Mankiw it can be argued that the magnitude of the supply shocks affects how the supply shocks affect inflation. Their model expanded traditional models to include the sticky-price assumption, and showed that the skewness of the distribution of relative-price change affected the relationship between inflation and supply shocks. (Ball & Mankiw, 1995) Dewachter and Lustig agreed with this model but argued that the inclusion of interaction between price-setters was essential for the model. Thus, emphasizing the importance of the behavior of inflation expectations simultaneously. (Dewachter & Lustig, 1998) One can thus deduce that supply shocks are inflationary, however, they are much more inflationary when the interaction between price-setters, and thus inflation expectation are included. Large supply shocks affect the price level disproportionately more than small shocks, because of menu costs of firms.

Mio and Sommer also emphasize the importance of inflation expectations in their models, and show that their models including inflation expectations outperform models such as Ball and Mankiw's model.

However, Ball and Mazumder argue against these ideas about inflation expectations and argue that in the post-Volcker period one can see that inflation expectations have changed to be 'anchored'. They expand on the past sticky-price model of Ball and Mankiw but come to the conclusion that the economy is a 'shock anchored' economy, and state that agents now trust that inflation will only fluctuate in the short-term, and will not persist. These expectations for inflation thus feed into the real inflation, and decreases the persistence of inflation in an economy (according to the Phillips curve).

This may be a result of past research that showed that shocks were not permanently inflationary, and that the effects of shocks on inflation gradually decreased back down to prior levels (for example Sommer). However, it was also emphasized that monetary policy has a prominent effect on the persistence of inflation (examined by Sommer and Hooker). Shocks to aggregate supply may have long lasting effects on inflation depending on the monetary policy and on the expectations of inflation by agents in the economy. It can thus be deduced that the monetary policy in the 80's and 90's (studied by Sommer) was ideal for keeping the persistence of inflation low.

Finally, it can be said that macroeconomic views on the effects of supply shocks on inflation have developed plenty since the 1970's. The models and their inclusion of new variables, aspects and ideas have made the modern Phillips curve what it is today, and has reminded macroeconomists that the classical dichotomy does not stand in relations to inflation being a purely monetary phenomena. Rather, supply shocks do have inflationary power, that is limited by inflation expectations, monetary policy, and the skewness of relative-price change distribution.

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