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Paper by invitation

Core Inflation Indicators for Saudi Arabia

Summary: This paper constructs and analyzes core inflation indicators for Saudi Arabia for the period of March 2012 to May 2014 using two alternative approaches: the exclusion method (ex food and housing/rent) and the statistical method. The findings of the analysis suggest that the ex food and housing/rent inflation is more volatile than the overall CPI inflation over the sample period. In contrast, the statistical core inflation is relatively more stable and less volatile. Moreover, the ex food and housing/rent inflation is only weakly correlated with headline inflation, whereas the statistical core inflation exhibits a stronger correlation. This combination of lower volatility and higher correlation with headline inflation makes the statistical method a much better choice for policymakers. From a monetary policy standpoint, using a bundle of core inflation measures, including both properly constructed exclusion and statistical methods, is more desirable, especially when variation across measures is widespread, as is the case in Saudi Arabia.

Key words: Consumer price index, Core inflation, Generalized dynamic factor model, Monetary policy.

JEL: C51, E31, E58.

The measurement of prices and monitoring of inflation is a key task for virtually every central bank in the world; this is certainly the case in Saudi Arabia. In order to accomplish this task, the Saudi Arabian Monetary Agency (SAMA) needs accurate data about domestic inflation, so that it can make appropriate policy decisions in a timely fashion. Simply put, the better the measure of underlying inflation, the higher the probability that proper policy decisions will be made. Most central banks, including SAMA, use overall consumer price indexes that have two inherent problems: (i) they are based on consumer expenditure surveys, which are used to derive expenditure-based weighting factors that have a potential weighing and substitution bias; (ii) they may contain measurement errors that can lead to measurement bias[1]. These potential problems could hinder an accurate assessment of inflationary (or deflationary) tendencies.

SAMA's central measure of inflation is based on the year-over-year growth rate of the consumer price indexes (CPI), which is released each month. In other words, it is the change in the monthly index compared to its value in the same month

[1] SAMA publishes CPI series for Saudi Arabia in its website and reports, but the Central Department of Statistics and Information (CDSI) is the authority that produces the CPI data for the Kingdom. For more information on the issue of measurement bias, see Michael F. Bryan and Stephen G. Cecchetti (1993).

of the previous year. Use of this measurement presents two immediate problems. First, it is obviously a lagging indicator of inflation, since it is based on price movements that have occurred over the period of an entire year. Thus, the price movement in the first month of the period carries as much weight as does the price movement in the last (12^{th} and most recent) month. The second problem is that it carries with it a considerable amount of inherent noise, oscillations, and other temporary shocks. This could lead to policy errors by the monetary authorities. To overcome these problems, SAMA ideally needs a measure of inflation that is at least somewhat predictive in nature (i.e., is more of a leading indicator, rather than a lagging) and also eliminates the noise, short-term oscillations, and other transitory shocks. Such a measure would reveal the true base, or core, inflation rate for the Saudi economy.

There are several ways of approaching the problem of constructing a core inflation measure. This includes the following:

(a) *The exclusion method*. This is the most widely used method, because it is simple and easy to understand. This method estimates core inflation by removing the prices of selected components from the market basket of goods and services that go into the calculation of the overall index. Ideally, in order to achieve the goal of constructing a core index, the components selected for exclusion should show short-term oscillations and a degree of volatility in their price movements. One example that is widely used, most notably in the United States, is the exclusion of food and energy prices from the index, due to their high volatility and the transient nature of their movement. Although food may seemingly be a logical candidate for exclusion, we do not advocate the exclusion of energy in a Saudi core inflation measure, for two reasons. First of all, Saudi Arabia is an oil producing country and its economy depends heavily on oil revenues. Specifically, the exports of crude oil and refined petroleum products provide about 85-90 percent of government revenues. These revenues, when recycled into the economy *via* government spending on goods, services, and transfer payments, can significantly boost aggregate domestic demand. This could result in demand-pull inflation, which, if sustained over a period of time, could raise the core inflation rate (see Mark A. Wynne 2008). Ryadh M. Alkhareif and William A. Barnett (2012) have shown that inflation rates in the Gulf area have peaked during periods of booming oil prices. The second reason for not excluding energy is that domestic energy prices are fixed by royal edict and are only infrequently adjusted. Thus, rather than being a source of volatility, domestic energy prices are a source of stability in the index. Any change in these fixed prices causes a one-time shock to the overall CPI, but it is concentrated in a few areas (primarily the housing and utilities and transportation sectors) and does not directly feed through into other sectors of the economy.

(b) *The trimmed means method*. This methodology considers only the central portion of a distribution by using limited-influence estimators that, in effect, disregard the outliers (Bryan and Cecchetti 1993). However, the trimmed mean method is not completely satisfactory. The optimal size of trimming is done through the use of criterion functions over the full sample, rather than being determined by a recursive estimation procedure, where the trimmed mean is constructed sequentially. In effect, this causes estimates to be biased toward particular periods (see Robert Rich and

Charles Steindel 2007). As a result, care must be taken to avoid any potential estimation bias when using the trimming index.

(c) *Core inflation measures based on statistical (or theory based) methods*. Such core inflation series are calculated using formal theoretical models such as vector autoregressive models and dynamic factor models. This methodology is the basis for the core inflation index described in this paper.

In order to construct a core inflation measure that minimizes random noise and short-term price movements, we chose to use the generalized dynamic factor model (GDFM), first mentioned by Filippo Altissimo et al. (2010). Use of this model enabled us to achieve two goals simultaneously: (1) separate the common shocks from the idiosyncratic counterparts; (2) extract the long-run common component part from the common shocks. It seems reasonable to model inflation in Saudi Arabia based on this approach, since there are two kinds of shocks an oil-exporting country could face - common shocks (i.e., those experienced by all oil exporters who are exposed to global commodity markets) and idiosyncratic (or country specific) shocks. Saudi Arabia has experienced major shocks of both types in the past decade. For example, three of the six GCC (Gulf Cooperation Council) countries (Saudi Arabia, the United Arab Emirates and Kuwait) showed actual declines in real GDP in 2009, while the economies of the other three showed marked slowdowns in real growth. This was due primarily to the decline in oil prices in late 2008 and the cut-back in Gulf oil production in 2009, a result of sluggish global demand on oil caused by the global financial crisis. In contrast, the Saudi stock market meltdown two years earlier, in 2006, was a good example of an idiosyncratic country specific shock, since it had little impact on other stock markets in the region.

Use of the GDFM makes it possible to identify the sources of price fluctuations, since it allows us to distinguish between common and sector-specific (idiosyncratic) shocks. The ability to identify the source of specific shocks gives the policymakers more information, so that they can effectively respond to the shocks with the appropriate policies. The idiosyncratic shocks contain errors that can lead to measurement bias; they also exhibit a weak correlation with both real and financial indicators, particularly the long-term movements of inflation (see, *inter alia*, Riccardo Cristadoro et al. 2005). The elimination of idiosyncratic shocks from the core inflation indicators should lead to a more robust and reliable core inflation measure. Thus, use of these core inflation indicators would provide useful tools that could be used to strengthen monetary policy at SAMA. Our core inflation data will also help financial analysts and economic agents explore price developments in Saudi Arabia and, more importantly, the interaction between inflation and other macroeconomic variables.

We strongly support the inclusion of oil prices and related variables (e.g., oil export revenues) in the construction of the core inflation indicators, since oil revenues are one of the key drivers for the Saudi economy. Between 85 and 90 percent of government spending in Saudi Arabia is financed *via* oil revenues, rather than by standard sources such as taxes and borrowing. Government spending on infrastructure projects and social programs has exploded in the 2004-2014 period, and this can act to increase domestic prices. Oil prices surged in the first six months of 2008, leading to higher oil export revenues for the Kingdom. The government's spending of these revenues triggered a record high inflation rate, with inflation reaching 11 percent year-over-year in mid-2008, as indicated by Alkhareif and Barnett (2012)[2]. Since the inflation rate in Saudi Arabia is driven in part by oil prices, it would be inadvisable to exclude energy prices from core inflation.

The remainder of this paper is organized as follows: Section 1 gives an overview of the generalized dynamic factor model, Section 2 describes the data used in the model's construction, Section 3 constructs core inflation indicators for Saudi Arabia, and Section 4 concludes the paper.

1. Methodology

The dynamic factor model is based on the theory that each variable in the dataset has two orthogonal components whose values can be determined only by decomposition using statistical analysis[3]. Such components are: (i) a common component that is highly correlated with the other macro variables that are included in the analysis and contribute to the new index; (ii) the idiosyncratic component, which is unique for each individual variable and therefore has no effect on the other variables that are part of the index (see Cristadoro et al. 2005). Thus, use of the GDFM methodology allows us to identify and remove the short-term fluctuations and sector-specific shocks, while retaining the long-term components, which we believe contain the essence of the core inflation information. Thus, our new core inflation indicator is based upon the common shared information that is embedded in the cross-section and time series characteristics of the variables in the dataset (see Wynne 2008).

This GDFM-based methodology uses two distinct smoothing procedures. First, a cross-sectional smoothing is performed, in order to net out the idiosyncratic (or sector specific) component of inflation, while maintaining the common component of the underlying inflation. The second step is to use time series smoothing in order to extract the long-term (longer than one year) common components. This step removes the high frequency movements of the common components (see Altissimo et al. 2010). Although these movements are shared with the other variables used, their high frequency oscillation means that they do not enter into the determination of the core inflation rate.

1.1 Generalized Dynamic Factor Model

The generalized dynamic factor model that we have used to construct our index was originally introduced by Altissimo et al. (2010). We have applied this methodology to our large-dimensional dataset that consists of economic variables displaying strong co-movements among themselves. More importantly, this dataset includes variables that economic theory tells us should be related to core inflation - e.g., oil prices and revenues, as well as government spending proxies. Unlike traditional econometric analysis (e.g., OLS regression), the lack of a large number of periods of observations (e.g., monthly data over just a few years) is not a hindrance. According to recent em-

[2] This inflation figure was published by the CDSI with a base year of 1999. The CDSI has recently changed the base year from 1999 to 2007 and hence inflation numbers have changed accordingly.
[3] Statistically speaking, orthogonal components are those that have no correlation with each other.

pirical studies, the GDFM approach appears to perform well in large cross-sectional datasets, especially when the number of cross-sectional series is larger than the number of time series observations (see, e.g., Cristadoro et al. 2005; James H. Stock and Mark W. Watson 2011).

GDFM methodology allows the identification of the various sources of price fluctuations by using a few common factors that can explain a large proportion of the covariation across economic series. The biggest advantage of GDFM is its ability to separate long-term movements of variables from short-term fluctuations. The underlying principle of the dynamic factor model is that each variable, x_{it} can be decomposed into the sum of two stationary, mutually orthogonal, and unobservable components, which we will refer to as the common component χ_{it}, and the idiosyncratic component ξ_{it}. Thus:

$$x_{it} = \chi_{it} + \xi_{it} . \tag{1}$$

The common component embodies the intrinsic GDFM principle that variables are more likely to be determined, in part, by a few common factors. Conversely, the idiosyncratic component represents a variable-specific shock that does not have an impact on other variables in the system.

However, it is necessary to carry our development process one step further. An inflation indicator that is free from errors and transitory turbulences is required. As an example, policymakers could conceivably make erroneous policy decisions because of the existence of measurement errors and short-term oscillations of the inflation indicator. The ability to filter out transitory shocks and seasonal noise is an absolute necessity, if a central bank is to monitor inflationary trends accurately. Thus, it is necessary to smooth and refine the common component χ_{it} in a further step, by using statistical techniques involving frequency domain analysis and spectral decomposition (see, e.g., Stock and Watson 2002). Like any stationary variable, the common component can be decomposed into a short-term component χ_{it}^S and a long-term component χ_{it}^L:

$$\chi_{it} = \chi_{it}^L + \chi_{it}^S . \tag{2}$$

This paper defines this long-term common component of inflation as being core inflation; thus, our goal is to estimate this long-term key variable. The estimation procedure exploits the generalized principal components techniques and frequency domain analysis. We use spectral density estimation techniques to convert the dataset back and forth between time domain and frequency domain through Fourier transformation systems. The exact estimation process that we followed is described in more detail in Alkhareif and Barnett (2013).

2. Data Descriptions and Sources

A total of 86 cross-sectional series were used to construct the statistical core inflation indicator, with monthly data from March 2012 to May 2014. This is a relatively short period of time, but data were limited for such a wide variety of data. The data were obtained from various sources such as the Bloomberg Database (2015)[4], CDSI (2015)[5], the FRED (2015)[6], the GCC-Stat (2015)[7], the International Financial Statistics (IFS) (2015)[8] and the SAMA (2015)[9]. To construct our core inflation indicators, we used prices including consumer price indexes and wholesale (producer) prices (WPI). Variables such as exchange rates and oil prices were also included in the computations of our core inflation indicators, as were interest rates on different types of financial assets, including overnight deposits, demand deposits, savings and time deposits and quasi-money. Government bonds and interest rate spreads were also used, along with the Divisia monetary indexes produced by Alkhareif and Barnett (2013, 2015). Specifically, we used their Divisia monetary aggregates (M1 and M2), monetary assets' user-cost prices, Divisia user-cost aggregates and dual prices. Because Divisia indexes exhibit a very significant relation with inflation rates in Saudi Arabia (see Alkhareif and Barnett 2013), using such measures toward constructing core inflation indicators for Saudi Arabia is greatly desirable.

As the first step in the analysis, the original data were normalized by subtracting their means and dividing by their standard deviations. There were only a few missing data items in our study; in these rare cases, we applied moving average interpolation to fill in the missing data. The stationarity of variables in the system is a key condition for using any dynamic factor model, especially for estimating the spectral matrix of the data, which was a necessary step in our procedure (see Mario Forni and Marco Lippi 2011 for more details). In order to ensure this stationarity, we transformed any non-stationary variables into a stationary series using the proper transformation methodology. In the case of variables in the dataset with I(1) cointegration, we used a log difference (delta log) transformation. Non-stationary variables with I(1) cointegration and negative values were, of course, only differenced. We then applied Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests to confirm their stationarity[10]. All quantities were seasonally adjusted using the X11 procedure.

3. Core Inflation Indicators for Saudi Arabia

Two core inflation measures were calculated in this study - the statistically-derived core inflation indicator described above and an ex food and housing/rent inflation

[4] **Bloomberg Business.** 2015. Bloomberg Professional. http://www.bloomberg.com/professional/ (accessed January 15, 2015).
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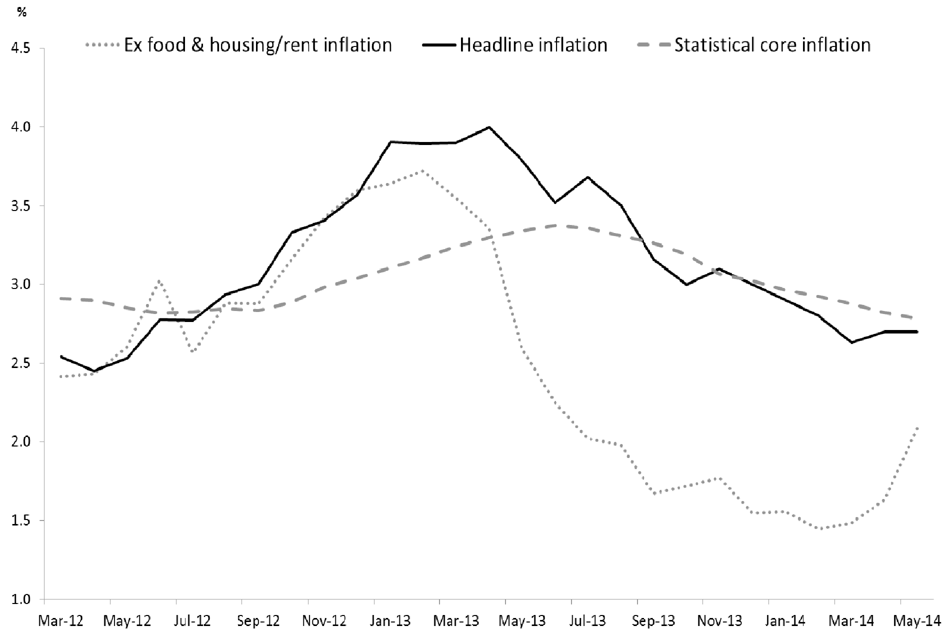
[10] Since we had a total of 86 variables in our study, including the results of the standard unit root tests was not feasible. The overall results of the unit root tests can be provided upon request.

index, which was calculated by simply excluding the two major categories and rebalancing the weights of those remaining. It should be noted that these categories are the largest in the Saudi CPI, comprising over 42 percent of the overall index.

Figure 1 depicts Saudi headline inflation *versus* the two core inflation measures over the period from March 2012 to May 2014, using monthly data. As was indicated earlier, all inflation figures are based on the change in the relevant monthly index from its 12-month-earlier value.



Source: Authors.

Figure 1 Headline Inflation vs the Two Core Inflation Measures

Both core inflation measures were predominantly below headline inflation over the entire period. However, significant divergence between the two core inflation measures occurred, starting in September 2012. The two measures moved in the opposite direction starting in early 2013, with the ex food and housing/rent inflation declining substantially. In contrast, the statistically derived core inflation continued to rise slightly through June 2013, before beginning a moderate decline that lasted through May 2014. One major cause of this divergence is that the statistical core inflation index takes into account the long-term movement of food and housing prices, while omitting the short-term fluctuations. On the other hand, the ex food and housing/rent measure of inflation omits both long- and short-run movements of these two components, an omission which could mislead policymakers[11].

[11] The omission of housing/rental prices from the simple core index is dissatisfactory, since it was the source of a considerable amount of the inflationary pressure in the 2006-2011 period. This component

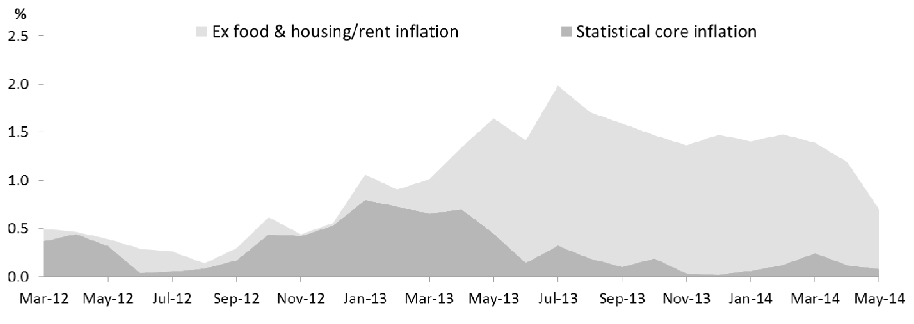
We find that the ex food and housing/rent inflation has the lowest mean value, and it is more volatile than both headline inflation and statistical core inflation. To measure inflation volatility, we compute the standard deviation (S.D.) for the Saudi inflation rate over the estimation period from March 2012 to May 2014. Table 1 indicates that the S.D. for the ex food and housing/rent core inflation is 0.8 percent; higher than the S.D. for both headline inflation and the statistical core inflation (0.5 percent and 0.2 percent, respectively).

Table 1 Summary Statistics (March 2012 - May 2014)

	Ex food and housing/ rent inflation	Statistical core inflation	Headline inflation (HI)
Mean	2.5	3.0	3.2
Max	3.7	3.4	4.0
Min	1.4	2.8	2.5
S.D.	0.8	0.2	0.5
Corr. with HI	0.6	0.8	1.0

Source: Authors.

Moreover, the absolute difference between headline inflation and ex food and housing/rent inflation greatly exceeds its statistical core inflation counterpart (Figure 2). This is in line with the results shown in Table 1, where the headline inflation is highly correlated with statistical core inflation as opposed to ex food and housing/rent inflation. Clearly, the statistical core inflation measure is better than the ex food and housing/rent inflation, as its volatility (S.D.) is lower and its correlation with the actual headline inflation is higher.



Source: Authors.

Figure 2 Gaps between Headline Inflation vs Core Inflation Measures (Absolute Terms)

has not displayed any volatility in the traditional "up and down" sense - between 1995 and 2006 the index remained almost perfectly constant, then started climbing at a 9.7 percent compound annual rate between 2006 and 2011. Over the past three years, the compound annual growth has been 3.4 percent, still somewhat higher than the overall inflation rate of 3.0 percent. Thus, the exclusion of housing prices from the simple core index gives a misleading signal to policy-makers, not only in the most recent two years, but also over the last decade.

It is interesting to note that the statistical core inflation average of 3.0 percent over the last two years is well within the 2-3½ percent "comfort range" for the underlying inflation target in the major countries. It is also very close to both the medium-term (3.0 percent compound annual average over the past three years) and long-term (3.4 percent compound annual average over the past ten years). We can conclude that this measure of core inflation is an accurate assessment of the underlying inflation rate and that this rate is within the "comfort range" of other economies.

4. Conclusion

Core inflation can be seen to be a useful indicator of long-term inflation trends. Constructing core inflation measures is of particular importance for policymakers at central banks. This study analyzes core inflation measures for Saudi Arabia based on two alternative methods: (a) a traditional exclusion-based index that excludes food and housing/rent inflation; (b) a statistical core inflation measure that uses an innovative general dynamic factor model methodology. The merit of using the statistical technique is that it permits us not only to separate common shocks from the idiosyncratic counterparts, but also to extract the long-term common component part from the common shocks - leading to smoother estimates.

The findings suggest that there is considerable variation between the two core inflation measures. The ex food and housing/rent definition of core inflation is less stable than is its statistical core inflation counterpart; furthermore, the GDFM statistical method tracks the headline inflation index more closely. However, an index based on the exclusion methodology applied properly (i.e., with the proper components excluded) would have the advantage of simplicity, and such an index could be included with the statistical core inflation indicator as one of several core inflation measures that would be made available to policymakers. This would be better than relying on a single (and possibly flawed) core inflation measure when examining inflationary trends.

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