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Dynamic Measures of Inflation

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While the definition of inflation is widely agreed upon -- "a continuing rise in the general price level" according to Merriam-Webster -- turning it into a concrete measure is much more difficult. One key obstacle is figuring out how to combine all of the price changes in the economy into a single number, and this price-index problem has occupied many economists for centuries.[1]

Roughly three approaches have been taken. One is rooted in statistics, seeing price indexes as estimators of an underlying concept, and focusing on probability models of price dynamics and how to deal with sampling uncertainty, consistency, efficiency, and so on. Another approach uses both mathematics and logic, proposing axioms that price indexes should satisfy, and from them deriving the formulas necessary to compute the indexes. A third approach uses models of economic choice, whether of producer or consumer behavior, and derives price indexes as dual measures of changes in welfare.

Across all approaches, most of the work so far has been static. While the price indexes are used to compare two dates, the theory underlying them gives little or no role to time. More recently, a dynamic approach has surfaced, in an attempt to measure inflation and to answer three separate questions. [2]

What are the consequences of central banks targeting different measures of inflation?

Kosuke Aoki and Pierpaolo Benigno began this literature by characterizing optimal monetary policy if there are two sectors in the economy, one where prices are flexibly chosen and another where they are sticky, so the relevant dynamics relate to price adjustment. [3] Michael Woodford already had shown that if there is only one sector with sticky prices, then even though social welfare depends on the volatility of both inflation and an output gap, stabilizing inflation alone achieves both goals (a result that Olivier Blanchard and Jordi Gali would later label "the divine coincidence.") [4] Aoki and Benigno found that, with two sectors, targeting only the sectoral price index in the sticky-price sector maximizes social welfare.

In my work with N. Gregory Mankiw, we set up a simple but general framework to study a stability-price-index (SPI), designed so that by committing to keep it on target, the central bank would stabilize economic activity. [5] We consider an economy with many sectors and four sources of heterogeneity in sectoral characteristics: the sluggishness of price adjustments; the cyclical sensitivity of optimal prices; the sector's size; and the magnitude of sector-specific shocks. Our first result is a generalization of Aoki and Benigno: the stickier are a sector's prices, the larger is its weight on the SPI. By targeting the prices in stickier sectors, the central bank minimizes the forecast errors that these firms make when fixing their prices ex ante.

Our second result justifies the practice of focusing on core measures of inflation, which exclude food and energy prices. We show that if a sector has very volatile specific shocks, like food and energy, then it requires large movement in its relative prices, so a central bank that stabilizes that sector's price will induce a mis-allocation of resources. Third, we find that more cyclical sectors receive a larger weight in the SPI because they serve as good indicators of the state of real activity. Finally, we find that, all else equal, the larger the weight of a sector on the final consumption basket, the smaller its weight on the SPI. It is important for welfare that larger sectors have their relative prices reflect changes in marginal rates of transformation, while unimportant sectors like gold provide a nominal anchor to the economy.

A numerical illustration on U.S. data suggests that the SPI puts a large weight on nominal wages. Wages are infrequently set, move closely with the business cycle, are relatively stable, and have a zero weight on the consumption basket. Efficient changes in real wages attributable to shocks to productivity can come through changes in goods' prices rather than through nominal wages. More recent work by Eusepi et al has explicitly constructed an optimal inflation target for the U.S. data using a quantitative business cycle model. [6] Their research concludes that a central bank with a strict-inflation target, while sticking to that target and ignoring fluctuations in output, can almost replicate the optimal outcomes of a flexible-inflation target, as long as the strict target is this unique measure of inflation.

Our model does not take into account intermediate goods. Subsequent research has shown that if the central bank's goal is to maximize social welfare, it will find it attractive to place a special weight on the price of intermediate goods, reinforcing the unique role of wages. [7]

How to separate absolute and relative price changes?

There is an important distinction between changes in prices that are equiproportional across all goods (absolute-price changes) and changes in the cost of some goods relative to others (relative-price changes). One bedrock principle of neoclassical economics is that absolute-price changes are neutral to any real decisions: if all prices exogenously doubled, then no relative trade-off would change so no one would behave differently. There is no money illusion if changes in the unit of account don't change anything real. [8]

This principle predicts that if we were able to come up with a measure of inflation such that all prices increase in exactly the same proportion and it is unrelated to any relative-price movements, then this should be unrelated to measures of real activity. This would be a measure of pure inflation, stripped away from all relative-price movements.

Michael Bryant and Stephen Cecchetti first noted that using dynamic factor analysis on a panel of price data allows one to

extract an equiproportional component as one of the factors.[9] In my work with Mark Watson, we note that the other factors are as just as interesting[10] : they measure relative-price changes attributable to an aggregate shock (to productivity or monetary policy for instance) and they provide a way to statistically purify the absolute-price changes from relative price movements.

Using U.S. quarterly data since 1959 on prices in 187 sectors, we find that for a typical sector, the idiosyncratic relative-price component accounts for roughly 70 percent of its variability. Macroeconomic shocks account for almost as much as one third of the movement in sectoral prices. Within aggregate sources of variation, pure inflation accounts for about 15-20 percent of the variability in the personal consumption expenditures (PCE) deflator, while a 2-dimensional index of aggregate relative-price changes captures most of the remainder. Even considering as many as four conventional measures of relative-price changes, the two relative-price factors in our baseline specification appear to be a more comprehensive measure of relative-price movements. Researchers must be cautious when testing the predictions for inflation from models with a single consumption good, because most of the variation in standard inflation indexes is associated with relative-price movements, which these models ignore.

Next, we turn to the Phillips correlation between PCE inflation and measures of real activity. The typical explanation for that correlation in economic models involves movements in relative prices. For instance, in sticky price or information models, only a fraction of price-setters adjusts to shocks, leading to a change in relative prices between those that adjust and those that do not, which then leads to changes in outputs. Our results support these theories: in the U.S. data, after controlling for relative goods' prices, the Phillips correlation becomes quantitatively negligible. If high inflation typically comes with low unemployment, it is because it also comes with changes in relative prices hidden within conventional inflation measures. At this macroeconomic level, there is no evidence of money illusion.

How to measure changes in the cost of living?

The definition of an economic cost-of-living price index is the change in wealth that would be required to leave a consumer equally well-off given today's prices as with yesterday's prices. The cost-of-living index is therefore the dual welfare measure associated with a consumption problem, so it is intrinsically linked to the setup of that problem.

The modern theory of consumption assumes that people maximize utility over many periods under uncertainty. According to this theory, measures of cost-of-living based on static models of consumer behavior have two crucial flaws. First, they suffer from an intertemporal substitution bias. When prices temporarily increase today, consumers will borrow from the future to afford their desire for smooth consumption. A static measure of inflation, like the consumer price index (CPI), will overstate inflation in this case. Second, cost-of-living measures suffer from an omitted variable problem. In the same way that the relative price of apples and bananas matters for the cost of living, so does the relative price of apples between today and tomorrow. In particular, because the relevant basket for the consumer includes goods today and in the future, and since asset prices measure the relative price of consumption over time, asset prices must enter a cost-of-living price index.[11]

I show that these two problems with static measures of inflation like the CPI are pervasive and then characterize the theoretical properties of a dynamic measure of the cost of living, which I label the DPI.[12] It differs from static measures in many ways. First, because consumers are forward-looking, so is the DPI, which implies that it moves with news of price changes. If today consumers learn that prices are going to rise in the future, they adjust their consumption immediately and their welfare changes today, so there is already inflation today. Second, an increase in prices today that is going to persist has a larger impact on welfare than a purely temporary one. In the limit, if the price change is permanent, then there is no scope for intertemporal substitution and the dynamic and static measures coincide. Third, and similarly, if the returns on an asset are close to being serially independent, as is the case with equity prices, then changes in the stock market have a close-to-zero impact on the DPI. Intuitively, because changes in stock prices do not change any relative returns from the present onwards, they have no effect on consumer choices and thus no effect on inflation. Fourth, durable goods like housing are special because they provide utility, like non-durables, but they also transfer wealth over time, like assets. If the price of a durable goes up temporarily, on top of the effect on inflation through consumption discussed above, there is an additional effect. Because the consumer now expects a capital loss on the durable it is holding, she is worse off, so inflation is even higher.

The next step in this research is to construct an annual DPI for the U.S. economy since 1960. The DPI is quite different from the CPI, with a correlation of only 0.34 between the two; in the past decade, average dynamic inflation has been 7.3 percent versus only 3.7 percent static inflation. The reason for these differences is that the DPI puts a great deal of weight on two series, house prices and bond prices. Until 2007, house prices were unusually high, while bond prices shot up in 2008. Both have combined to yield high inflation.

Conclusion

While the research described above has many new results, one old result keeps re-surfacing: your optimal measure of inflation depends on what you want to use it for. There is no universal best price index, but rather different indexes depending on what you are trying to measure. Economists are as guilty as laymen of falling into the complacency of using popular measures of inflation without giving too much thought to whether these are the right measures for the question at hand. I have learned that asking this question every time I want to look at inflation often yields surprising answers.

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1. E. Diewert, "The Early History of Price Index Research," NBER Working Paper No. 2713, September 1988, traces the history of price index research to as early as the beginning of the eighteenth century.

2. One use of dynamic measures of inflation that I will not cover is as deflators to obtain real measures of GDP. See S. Basu and J. Fernald, "Aggregate Productivity and Aggregate Technology," European Economic Review *46 (2002), pp. 963-91.*

3. K. Aoki "Optimal Monetary Policy Responses to Relative-Price Changes," Journal of Monetary Economics, 48 (2001), pp.

55-80, and P. Benigno "Optimal Monetary Policy in a Currency Area," Journal of International Economics *63 (2003), pp. 293-320.*

[4.] *M. Woodford, "Inflation Stabilization and Welfare," NBER Working Paper No. 8071, January 2001, and O. Blanchard and J. Gali, "Real Wage Rigidities and the New Keynesian Model," NBER Working Paper No. 11806, November 2005.*

[5.] *N. G. Mankiw and R. Reis, "What Measure of Inflation Should a Central Bank Target?" NBER Working Paper No. 9375, December 2002.*

[6.] *S. Eusepi, B. Hobijn, and A. Tambalotti, "CONDI: a cost-of-nominal-distortions index", FRB New York Staff Report 367, 2009.*

[7.] *K. Huang and Z. Liu, "Inflation Targeting: What Inflation Rate to Target?"* Journal of Monetary Economics *52, 2005, pp. 1435-62, and B. Strum, "Monetary Policy in a Forward-Looking Input-Output Economy,"* Journal of Money Credit and Banking *41, 2009, pp. 619-50.*

[8.] *D. Hume's Principles of Political Discourses (1752) added the further proposition that, in the long run, change in the stock of money leads to proportional changes in absolute prices. This produces the more controversial result of monetary neutrality.*

[9.] *M. Bryan and S. Cecchetti, "The Consumer Price Index as a Measure of Inflation," NBER Working Paper No. 4505, October 1993, and M. Bryan, S. Cecchetti, and R. Wiggins II, "Efficient Inflation Estimation," NBER Working Paper No. 6183, September 1997.*

[10.] *R. Reis and M. Watson, "Relative Goods' Prices and Pure Inflation," NBER Working Paper No. 13615, November 2007.*

[11.] *A. Alchian and B. Klein, "On a Correct Measure of Inflation,"* Journal of Money Credit and Banking *, 5, 1973, pp. 173-91, first emphasized that a dynamic measure of the cost-of-living must include asset prices.*

[12.] *R. Reis, "A Dynamic Measure of Inflation," NBER Working Paper No. 11746, November 2009.*

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