Are Chinese Growth and Inflation Too Smooth? Evidence from Engel Curves

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Abstract

China has experienced remarkably stable growth and inflation in recent years according to official statistics. We construct alternative estimates using detailed information on Chinese household purchasing patterns. As households become richer, a smaller fraction of total expenditures are spent on necessities such as grain and a larger fraction on luxuries such as eating out. We use systematic discrepancies between cross-sectional and time-series Engel curves to construct alternative estimates of Chinese growth and inflation. Our estimates suggest that official statistics present a smoothed version of reality. Official inflation rose in the 2000's, but our estimates indicate that true inflation was still higher and consumption growth was overstated over this period. In contrast, inflation was overstated and growth understated during the low-inflation 1990's. Similar patterns emerge from the data whether we base our estimates on major categories such as food or clothing as a fraction of total expenditures or subcategories such as grain as a fraction of food expenditures or garments as a fraction of clothing expenditures.

Keywords: China, New Goods Bias

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1 Introduction

China's growth experience over the past two decades has been an unparalleled economic miracle according to official statistics. Figure 1 plots official statistics for Chinese GDP growth, urban consumption growth and inflation. China has grown substantially faster than any other country over this period, with average output growth over 9% per year and average urban consumption growth close to 7% per year. Growth rates have, furthermore, been remarkably stable, rarely dipping below 5%, even over the tumultuous last few years. Following a bout of inflation in the early 1990's, China's inflation has been low and relatively stable, averaging less than 2% and never rising above 6% since 1997 according to official statistics.

While few would dispute that China has undergone a remarkable economic transformation, China's official statistics remain controversial. National accounts measurement is challenging under the best of circumstances, and all the more so in a rapidly growing economy. The "new goods" or "quality change" bias is perhaps the best known of the biases that afflict the measurement of inflation and growth. Such biases can lead standard methods to systematically overestimate inflation and underestimate GDP growth because standard methods fail to account for the fact that new products tend to be introduced at lower quality adjusted prices than the products they replace—say the replacement of last year's television model by a new and improved model.[1] Standard methods for constructing price indexes can also make inflation appear too smooth in the face of rapid product turnover, as a consequence of "product replacement bias" (Nakamura and Steinsson, 2012).

Political tampering is another important concern regarding growth and inflation statistics, given the highly politically sensitive nature of these statistics. In China, concerns about inflation are one factor often cited as contributing to the discontent that lead to the 1989 Tiananmen Square protests. The remarkable stability of growth and inflation statistics over the past two decades have undoubtedly been an important source of popular support for the Chinese Communist Party. Li Keqiang, the current prime minister of China, has said that Chinese regional GDP statistics are "man-made" and therefore "unreliable" and that he relies on electricity consumption, rail cargo volume and bank lending to gauge the economy (Reuters, 2010).

In this paper, we construct new growth and inflation statistics for China for the period 1995-

[1] Important papers on "new goods" and "quality change" bias include Court (1939), Griliches (1961), Nordhaus (1998), Bils and Klenow (2001), Hausman (2003), Pakes (2003), Boskin et al. (1996), Bils (2008), Moulton and Moses (1997) , Abraham et al. (1998), Triplett (1997) and Hobijn (2002). Erickson and Pakes (2011) develop an experimental hedonic price index for televisions that accounts, among other things, for price rigidity. Goldberg et al. (2010) show that new imported varieties contributed substantially to effective price declines for Indian firms after a trade liberalization. Reinsdorf (1993) studies the related idea of "outlet substitution bias."

2011. The approach we use is base on Engel curves—the empirical finding that as households become richer, a smaller fraction of total expenditures are spent on necessities, whereas a larger fraction are spent on luxuries. Such Engel curves have been documented in a wide variety of countries and time periods (see, e.g., Deaton and Muellbauer, 1980).[2] The basic logic of our approach is to exploit shifts in observed cross-sectional Engel curves over time to "back out" a bias correction factor for inflation and growth. A simple approach would be to compare Engel curves for different years. If the Engel curve in one year is systematically shifted down relative to the Engel curve for an earlier year after controlling for the relative price of the good in question – i.e., the expenditure share is lower for a given level of measured expenditures – one might conclude that measured expenditure growth is biased downward and measured inflation is biased upward. We employ a "difference-in-difference" version of this idea. This general approach to measuring growth and inflation was pioneered by Nakamura (1996), Hamilton (2001) and Costa (2001) and employed by these authors to measure new good bias in the US.

To estimate Engel curves for China, we develop a harmonized dataset on Chinese consumer expenditures at the province and income-group levels based on Chinese urban household survey data. In line with previous work for China and other countries, we find that as households become richer, they spend a smaller fraction of total expenditures on food, and a smaller fraction of food expenditures on staples such as grain, but spend a larger fraction on luxuries such as eating out.

Our bias adjusted estimates of inflation are highly correlated with official statistics. However, our estimates suggest that official statistics present a smoothed version of reality. We find that inflation was overestimated and growth was underestimated by several percentage points per year in the late 1990's. During this period, official inflation was low or slightly negative, and our Engel curve based measure of inflation is even lower. The flip-side of this is that we estimate a very high growth rate for urban consumption over this period—above 10% per year in each year from 1996 to 2002. Our estimates indicate a reversal in the direction of the bias in the recent period. Since 2002, official inflation statistics have risen only modestly, but our Engel curve based inflation estimates have risen much more. Our estimates imply that urban consumption growth in China has slowed substantially over the past decade, and dipped into negative territory in 2007 and 2008. One reason for the low growth in standards of living in 2007 that we measure may be a large negative supply shock to pork that occurred in China in that year.

Demand shocks are an important concern in assessing Engel curve estimates of growth and

[2] See Gale and Huang (2007) for recent work estimating Engel curves for China.

inflation. One might worry, for example, that the shifts in the food Engel curve we observe arise from shifts in households' preferences for food rather than biases in official statistics. What is remarkable about the Chinese data, however, is the pervasive nature of the Engel curve shifts both within and outside of food, and the systematic patterns in these shifts both for necessities and luxuries. Estimates of our Engel curve model based only on subcategories of food (excluding the food share itself) yield similar results to our baseline pooling analysis. As do estimates based on subcategories of food-at-home (eliminating the effects of preference shifts between food-at-home and eating out). As do estimates based on sub-categories of clothing, and those based on upper-level categories of consumption such as clothing and household appliances. For demand shocks to explain our findings, there would need to be demand shocks in a large number of different categories that all produced very similar Engel curve shifts.

Another important concern regarding the Engel curve methodology we employ is that we may not be accurately accounting for the effects of relative prices on consumer demand. Again, the pervasive nature of the Engel curve shifts means that the measurement or misspecification errors would have to have systematic patterns across many categories of necessity and luxury goods. However, the qualitative patterns of relative price movements are quite different. For example, the evolution of the price of food relative to total expenditure is quite different from that of grain relative to total food. The nature of the bias in the price elasticity would, therefore, also have to vary in a somewhat intricate way across goods to explain the patterns we find.

Our results are also robust to estimating separate Engel curves for the pre-2002 and post-2002 periods. This exercise addresses the concern that the slope of the Engel curve may have changed over time as Chinese consumption grew. Finally, while our baseline analysis uses aggregated data for Chinese provinces, we have carried out an analogous Engel curve analysis using expenditure data aggregated by income group, with qualitatively similar results. Moreover, we have re-estimated our model using micro-data from the China Household Income Project (CHIP). For the period over which the samples overlap, the CHIP generates qualitatively similar estimates of the biases to our baseline approach.[3]

The Engel curve approach we employ is based on the idea that while measuring overall growth and inflation using standard national income and product account methods is very difficult because of new goods bias, quality change bias, and substitution bias, measuring expenditure shares is

[3]Unfortunately, only the 1995 and 2002 waves of the CHIP data both overlap with our sample period and are available to us, so we are only able to compare the price and income elasticities and the cumulative bias estimates for 1995 versus 2002.

relatively simple. Furthermore, the headline growth and inflation statistics may be subject to political tampering but household expenditure data are less likely to be tampered with since they receive much less attention.

In addition to the papers we mention above, our work is related to a growing literature that uses Engel curve approaches to infer various aspects of economic growth. Aguiar and Bils (2011) use Engel curves to derive an alternative estimate of the growth in US consumption inequality. Almas (2012) uses Engel curves to estimate biases in purchasing power parity statistics. Young (2010) uses related methods to generate alternative estimates of African growth. Bils and Klenow (1998) use Engel curve methods to test the predictions of various business cycle models.

For the case of China, Xu and Zeng (2009) (in Chinese) estimate Engel curves for food, and derive the implications for the CPI bias over the 1997-2006 period, concluding that there have been no significant biases in Chinese inflation except in 1997. However, two fundamental differences between their work and ours are that they introduce an ad hoc dummy variable that accounts for shifts in the Engel curve in the post-2000 period—effectively absorbing any bias over this period, and that they do not include regional fixed effects, and instead divide the regions into two groups as a way of capturing the cross-sectional heterogeneity. Almas and Johnsen (2012) apply Engel curve methods to the 1995 and 2002 waves of the CHIP survey to construct a "regional price index," finding that inflation has been higher in rural than in urban China. Woo and Wang (2011) apply an Engel curve approach to a novel survey data set on household income to construct alternative estimates of income inequality in China. Both Almas and Johnsen (2012) and Woo and Wang (2011) find that official statistics underestimate income inequality in the recent period. Filho and Chamon (2007) apply an Engel curve approach to infer inflation biases from the food share in the CHIP data over the 1998-2005 period, documenting an upward bias in inflation (and downward bias in growth) over this period. Numerous papers have carried out related exercises for other countries: Beatty and Larsen (2005) for Canada, Larsen (2007) for Norway, Gibson, Stillman, and Le (2008) for Russia, Barrett and Brzozowski (2010) for Australia, Gibson and Scobie (2010) for New Zealand, Chung, Gibson, and Kim (2010) for Korea, and Filho and Chamon (2012) for Brazil and Mexico.

The paper proceeds as follows. Section 2 describes the data. Section 3 presents illustrative evidence on cross sectional Engel curves in China and how they shift over time. Section 4 presents our empirical model and the resulting estimates of biases in Chinese inflation and growth statistics. Section 5 presents our adjusted estimates of Chinese inflation and growth. Section 6 discusses the hog cycle of 2007, a supply shock to pork that helps explain why the standard of living for Chinese consumers fell in 2007 according to our estimates. Section 7 concludes.

2 Data and Institutional Background

Our main source of data is the yearbooks on urban household expenditures compiled by the Chinese National Bureau of Statistics. These yearbooks provide data on per capita monthly expenditures on disaggregated products for Chinese urban households. Most of our analysis is estimated using province-level expenditure data. In our robustness analysis, we also make use of an analogous dataset stratified by income group.

In addition to the expenditure data, we use CPI price data to account for potential changes in relative prices across commodities (but not the overall level of inflation, which we assume is measured with error). Finally, we incorporate a number of demographic controls in our analysis: household size, the number of people earning income (including non-wage income such as retirement earnings) per household, the number of people employed per household, the average sex ratio, the unemployment rate, the child-dependency ratio, and the elderly-dependency ratio.

We have extensively analyzed the data to eliminate inconsistencies and harmonize the data across years. We have also filled in gaps in digital sources from hard copy sources. The exact data sources, and the details of how we compiled the data are described in appendix A.

For our Engel curve approach to work, it must be the case that household expenditure shares are the consequence of optimizing decisions on the part of households. It is therefore important that household consumption decisions are not contaminated by rationing. In China, rationing was completely phased out by 1996 (and mostly phased out by the early 1990's). Price controls do not pose a problem for our approach, since we do not make any assumptions about the supply-side of the economy, but these too were mostly phased out by the mid-1990's. Concerns about rationing lead us to restrict attention to expenditure data from 1995 onward.

3 Illustrative Evidence

The logic of the Engel curve approach we employ is very simple. To illustrate how it works, Figure 2 plots the share of food in total expenditures as a function of log total expenditures for different income groups in China. The top panel plots this for 1995, 1998 and 2000, while the bottom panel plots 2006 and 2008. In each case, the food share is adjusted for both movements in relative prices and an income group fixed effect using the methods laid out in section 4. It is clear from the figure that there is a strong negative relationship between the food share and total expenditures across these income groups in each year. In other words, richer households spend a smaller fraction of their income on food.[4] This empirical relationship was first widely recognized after the work of Engel (1857, 1895) and is referred to as an Engel curve for food.

A second—more curious—pattern that emerges from this figure is that the Engel curves appear to "shift" downward over time between 1995 and 2000. In other words, for a given level of total expenditures, as measured by official statistics, households appear to spend successively lower fractions of their total expenditures on food over this period. One possible explanation for these shifting Engel curves—the one we explore in this paper—is that they arise from biases in official inflation statistics. If the change in the CPI measure used to deflate the real expenditures plotted on the x-axis is overstated, this will lead the points for, say, 2000 to be plotted too far to the left relative to the points for 1995—accounting for the apparent shift. A similar pattern of shifting Engel curves in the U.S. led Hamilton (2001) and Costa (2001) to conclude that there was a substantial downward bias in official U.S. growth statistics and an upward bias in the U.S. CPI inflation rate due to new goods bias.

In panel B of figure 2, we again see that the Engel curve appears to shift, but this time in the opposite direction. The Engel curve for 2008 lies above the Engel curve for 2006. This means that for a given level of total expenditures, as measured by official statistics, households appear to allocate a higher fraction of their total expenditures on food in 2008 than in 2006. This suggests that the official growth statistics were too high between 2006 and 2008, and the official inflation measures were too low. The upward shift in the Engel curves coincided with a substantial increase in official measures of inflation (see Figure 1). The Engel curve approach suggests that true inflation increased by even more than official measures of inflation indicate.

We can redo this analysis using regional data on expenditure shares—the main data source used in our paper. While the regional Engel curves are more noisy, the same patterns emerge. Figure 3 plots Engel curves for food across different regions in China for the same years as Figure 2, adjusted for both movements in relative prices and a region fixed effect using the methods laid out in section 4. The figure shows that as regions become more affluent they spend a smaller fraction of their total expenditures on food. But as in Figure 2, these Engel Curves seem to shift over time. Just

[4]Given the income group fixed effects in our specification in section 4, the negative slope of this relationship is identified from the fact that income groups with more rapidly growing expenditures see a larger drop in their food shares.

as in the case of the income group analysis, the Engel curves shift downward from 1995 to 2000 (indicating an upward bias in official inflation) and then upward from 2006 to 2008 (indicating a downward bias in official inflation).

Figure 4 plots Engel curves for grain as a fraction of total food expenditures. Since grain is a necessity, the Engel curves slope downward. Moreover, we observe a similar pattern of shifting Engel curves as in the case of food. While the grain share Engel curves shift downward from 1995-2000, they shift upward from 2006-2008. That these patterns arise for grain as well as for food bolsters the case that both patterns arise from a common cause— mismeasurement in official statistics. We show in section 5 that similar patterns arise for a much wider range of necessities beyond just food and grain, and that the opposite patterns arise for luxuries such as eating out and pre-made garments.

4 Engel Curve Estimation

We proceed now to use the patterns described in section 3 to derive alternative estimates of Chinese growth and inflation. The methods we use are based on earlier work by Nakamura (1996), Hamilton (2001) and Costa (2001). We extend these methods to allow for pooling across Engel curves for different commodities. This pooling approach improves the precision of our estimates, and lessens their sensitivity to idiosyncratic measurement errors and demand shocks.

Our estimates are based on the following log-linear model for the expenditure share of commodity k in region i at time t:

$$\omega_{i,t}^k = \psi_i^k + \beta^k \log(C_{i,t}/P_{i,t}) + \gamma^k \log(P_{i,t}^k/P_{i,t}) + \sum_x \Theta_x^k X_{i,t} + \epsilon_{i,t}^k, \tag{1}$$

where $C_{i,t}/P_{i,t}$ denotes real total expenditures (and $P_{i,t}$ is the true aggregate price level), $P_{i,t}^k$ denotes the relative price of commodity k, $X_{i,t}$ is a set of demographic controls, ψ_i^k denotes a region-good fixed effect, and $\epsilon_{i,t}^k$ is a residual.[5]

Equation (1) describes how the expenditure share for good k varies with real total expenditures and the good's relative price. The coefficient on real total expenditures, β^k, measures the extent to which households spend a larger share of total expenditures on good k as they become richer. For

[5] A linear relationship of this type between expenditure shares and log income arises from Deaton and Muelbauer's (1980) Almost Ideal Demand System. One caveat is that the "price index" $P_{i,t}$ in equation (1) differs from the true cost-of-living index due to the non-homotheticity of preferences. Beatty and Crossley (2012) show that this implies that the CPI bias implied by the Hamilton-Costa method may also reflect differences in inflation for individuals at different points in the income distribution.

example, the well-known negative relationship between the food share and total expenditures would imply $\beta^k < 0$. More generally, expenditure shares decline with total expenditure for necessities ($\beta^k < 0$) and rise for luxuries ($\beta^k > 0$).

In practice, the true price level and the true price of good k are measured with error. Let $\tilde{\pi}^k_{i,t}$ denote the measured cumulative inflation for good k in region i between periods 0 and t. Then we have

$$\log P^k_{i,t} - \log P^k_{i,0} = \tilde{\pi}^k_{i,t} + \mu^k_{i,t}, \tag{2}$$

where $\mu^k_{i,t}$ denotes the cumulative bias in the measurement of inflation. Define measured cumulative inflation for all prices $\tilde{\pi}_{i,t}$ and the cumulative bias for all prices $\mu_{i,t}$ analogously. Using these concepts to eliminate the unobserved true prices $P_{i,t}$ and $P^k_{i,t}$ from equation (1) yields

$$\omega^k_{i,t} = \hat{\psi}^k_i + \beta^k \log C_{i,t} - \beta^k \tilde{\pi}_{i,t} - \beta^k \mu_t + \gamma^k (\tilde{\pi}^k_{i,t} - \tilde{\pi}_{i,t}) + \sum_x \Theta^k_x X_{i,t} + \epsilon^k_{i,t}, \tag{3}$$

where $\hat{\psi}^k_i = \psi^k_i - \beta^k \log P_{i,0} + \gamma^k (\log P^k_{i,0} - \log P_{i,0})$ and we have made the assumption that the inflation bias is constant across commodities and regions (i.e., $\mu^k_{i,t} = \mu_t$).

Our interest centers on the inflation bias term μ_t. It is straightforward to estimate μ_t from the Engel curve for a single product k, such as food. To do this, we simply replace the terms $\beta^k \mu_t$ by time fixed effects and then estimate the resulting equation by OLS. We can then recover μ_t by dividing the estimated time fixed effects by the estimated coefficient β^k. This is the original Hamilton-Costa approach (with the slight difference that they have individual level data on expenditures but price indexes that vary only by region).

Suppose, however, that we wish to estimate the bias term μ_t pooling information across more than one commodity. In this case, we wish to allow the slope of the Engel curve, β^k, to vary across commodities, while μ_t is common across all commodities. This specification no longer admits a representation that can be estimated using ordinary least squares. Hence, for the pooled specifications we consider, we estimate equation (3) using non-linear least squares on a pooled dataset containing the expenditure shares of multiple commodities.

Since we allow for region fixed effects, the slope of the Engel curve β^k is identified from what happens to the expenditure share in one province versus another when its relative consumption increases. In other words, a good is a necessity if regions whose consumption is growing particularly quickly relative to other regions also have expenditure shares for the good that are falling rapidly. Our estimates are not, therefore, affected by constant differences in consumption preferences across regions.

5 Results on Inflation and Urban Consumption Growth

Figure 5 presents our baseline Engel curve based estimates of inflation over the period 1996-2011, alongside official inflation statistics. Our baseline specification pools information from the Engel curve for food expenditures as a fraction total expenditures with 14 separate Engel curves for expenditures on 14 subcategories of food (e.g., grain, meat, or eating out) as a fraction of food expenditures.[6] The dashed lines present two standard error bands. The standard errors are clustered by commodity to allow for arbitrary time series correlation of the error term.

According to our Engel curve based estimates, official inflation statistics present a smoothed version of reality. Our Engel curve based inflation series is highly correlated with the official inflation series, but substantially more volatile. In the late 1990's, China experienced a mild deflation according to official statistics, which the IMF attributed to commodity cost declines, WTO-related tariff cuts, productivity gains from reforms to state-owned enterprises and greater competition (IMF, 2003). Our inflation series indicates that there was considerably more deflation over this period than official statistics suggest. On the other hand, in the late 2000's, inflation started to rise modestly according to official statistics, peaking in 2008. Our estimates suggest that true inflation was considerably higher than official statistics over this period.[7]

It is important to note that the official inflation rate plays no role in the construction of our Engel curve based inflation series. Intuitively, our inflation series is backed out from expenditure data as a factor that is needed to undo shifts over time in the cross-sectional Engel curves for various expenditure shares. There is, therefore, no mechanical reason for the strong correlation we observe between the official CPI and our adjusted inflation measure.[8]

The flipside of understated inflation is overstated growth. This follows from the fact that inflation statistics are used to transform nominal growth rates into real growth rates. Figure 6

[6]The 14 subcategories of food are grain, meat, beans, starch, egg, oil, milk, baked goods, condiments, sugar, vegetables, fruit, fish and eating out. These categories are chosen as all those for which it was possible to construct harmonized consumption series over time. We exclude the "sugar, tobacco, liquor and beverage" category because it is a composite category.

[7]The official inflation measure in Figure 5 is the urban CPI. However, Figure A.1 shows that the urban and total CPI measures are very similar. Moreover, total nominal consumption as measured in the household survey is very similar to total nominal consumption as measured by the Chinese national accounts. This is illustrated in Figure A.2. The only significant discrepancy is a spike in the household survey in 2002 that may have arisen from the redefinition of some of the categories in that year.

[8]The fact that measured inflation is one of the regressors in equation (3) may give the impression that measured inflation plays a role in the construction of our bias estimates. This is not the case. We could have run regression (3) without measured inflation as a regressor. In this case, the evolution of the time fixed effects (divided by β^k) would yield the evolution of true inflation. Including measured inflation as an additional regressor simply changes the interpretation of the time fixed effects so that they yield the inflation bias as opposed to true inflation.

presents the implications of our Engel curve estimates for Chinese urban consumption growth. The figure shows that while official statistics suggest a highly stable, and slightly upward sloping trend in Chinese urban consumption growth over the period 1996-2011, our Engel curve based estimates of urban consumption growth indicate considerably more volatility and a marked slowdown in the late 2000's. According to our estimates, urban consumption growth in China was substantially higher than official statistics indicate in the late 1990's—above 10% per year in each year from 1996 to 2002 and above 15% per year between 1998 and 2000. Since then, growth has been lower, in particular, dipping into negative territory in 2007 and 2008.

Recall that our estimates are driven by changes over time in the expenditure shares for necessities versus luxuries. Rapidly falling expenditure shares for necessities suggest that growth is high (and inflation low, all else equal), while falling or slowly rising expenditure shares for luxuries suggest the opposite. Table 1 presents the income coefficients β^k and the price coefficients γ^k from our baseline pooled estimation of equation (3). Our estimate of β^k for food is negative, indicating that food is a necessity. Our estimate of β^k for grain and meat are also negative indicating that grain and meat are necessities within food (i.e., the share of food expenditures that go towards grain and meat fall as total expenditures rise). On the other hand, our estimate of β^k for milk, fruit and eating out are positive, indicating that these are luxuries within food. It is crucial for our analysis that many of the coefficients on total expenditures differ substantially from zero. It is only because expenditure shares change in a systematic way with total expenditures that we are able to draw inferences about growth and inflation from variation in expenditure shares.

Figure 7 presents the evolution of the expenditure share on food as well as the share of food expenditures on grain and eating out over the period 1996-2011. Both the food share and the grain share within food declined rapidly in the late 1990's and the share of food expenditures that go towards eating out rose rapidly. These rapid changes in expenditure patterns then decelerated markedly after 2002. If other things are equal, this suggests a marked slowdown of growth in urban consumption after 2002.

Model misspecification is an important concern in assessing Engel curve estimates of growth and inflation. One might be concerned, for example, that the rapid declines in expenditure shares for food in the late 1990s reflect changing household preferences that are not accounted for by our model. To address this concern, we present results for many different product categories. The fact that we find common patterns regarding the shifts in Engel curves over time across a large number of these categories suggests that these shifts arise from a common cause—mismeasurement in official inflation statistics—as opposed to product specific changes in household preferences.

As we discuss above, our baseline specification presented in Figures 5 and 6 is based on pooled data for food and 14 subcategories of food. Figure 8 compares our baseline estimates for inflation with inflation estimates based on the food share alone and inflation estimates based on pooled data for the 14 subcategories of food alone. There is no mechanical reason why these two specification should yield the same results regarding inflation bias. Yet the figure shows that both of these components of our baseline specification yield very similar results for inflation. This similarity across the predictions of the different models is reassuring, since it makes it less likely that our results are driven by idiosyncratic demand shocks or measurement error.

The next three figures present results based on several additional Engel curves. Figure 9 presents estimates of inflation using the share of eating out—a luxury—alone. It also presents estimates based on pooling across various sub-categories of food at home, such as grain, meat and vegetables as a fraction of food at home. Both of these specifications yield qualitatively similar results—larger deflation in the late 1990s and larger inflation in the 2000s than official inflation statistics.

Figure 10 is analogous to Figure 8 except that it is based on the Engel curves for clothing and subcategories of clothing.[9] The specification pooling clothing and subcategories of clothing and the specification pooling only the subcategories of clothing both yield results that are similar to our baseline results. The specification based on the Engel curve for clothing alone yields similar results for the late 1990s and late 2000s, but somewhat different results for 2000-2003. It is clear from the figure that when the Engel curve for clothing is pooled with the Engel curves for the subcategories of clothing the Engel curve for clothing contributes very little to the pooled estimates suggesting that there is less information about inflation in the Engel curve for clothing than the Engel curves for the subcategories of clothing.

Figure 11 presents results from a specification that pools data from the Engel curves of all of the major expenditure categories of consumption—food, clothing, household appliances and services, transportation and communication, education, recreation and culture, housing, and health care. Since one might be concerned that there is a large amount of government intervention in housing and health care, the figure also presents results of pooling only the first five categories. Finally, the figure also presents results excluding food in addition to housing and health care. All three of these specifications yield qualitatively similar results—larger deflation in the late 1990s and larger inflation in the 2000s than official inflation statistics.

[9] The four subcategories of clothing are garments, clothing material, shoes and other clothing, laundry and tailoring.

A potential worry with our methodology is that we might not account correctly for the effect of relative prices on expenditure shares. Figure 12 plots the evolution of the price of food relative to all goods, and the price of five large subgategories of food relative to food. These are the main expenditure categories in our baseline specification (Figure 5). These relative price series follow markedly different patterns over the time period of our analysis. The relative price of Food/Total and Meat/Food fall in the late 90s and rise in the 2000s, Eating-out/Total does the opposite, Grain/Food and Fish/Food fall (unevenly) throughout, while Vegetables/Food rise (unevenly) throughout. The large amount of heterogeneity in the evolution of relative prices and the consistency of our results on inflation across many different expenditure categories makes it difficult to construct a story based on movements in relative prices that accounts for our results.

Let's nevertheless consider several concerns along these lines. First, our empirical methodology implicitly assumes that all variation in prices is due to supply shocks. If this is not the case, we may be underestimating the price elasticity of demand. For food, we estimate $\gamma^k > 0$ implying that an increase in the relative price of food raises the expenditure share of food. In other words, we estimate the price elasticity of demand for food to be lower than one. Suppose we underestimate the true price elasticity, implying that the true γ^k is smaller than our estimates suggest. In this case, our Engel curve methodology would imply even larger divergences between true and official inflation (in the same direction) to fit the observed patterns in expenditure shares. A similar argument applies to the Engel curve estimates based on eating out, since the pattern of price movements for that category is opposite that of food.

A different concern would be that we underestimate γ^k, perhaps due to attenuation bias (most of our estimated γ^k are positive but small). In the case of the Engel curves for food, meat, and eating out, this could potentially help explain the overall pattern in the difference between our estimate of inflation and official inflation. But this is not the case for grain, fish, vegetables or most of the categories outside of food.

A related concern is that the bias in official inflation statistics may not be uniform across sectors. We make the simplifying assumption that the inflation bias is uniform across sectors. If, however, the bias in official inflation statistics is, e.g., less severe for food products—perhaps because new goods bias is larger in other categories—the data series we use for the relative price of food will show a slower increase in the relative price of food than actually occurred. If this bias were constant over time, it would lead us to overstate inflation uniformly. We are not aware of any reason why this bias might vary over time and across products in a way that would explain the patterns we find.

In Figures 13 and 14 we return to using the same product categories as in our baseline specification. In these two figures we make changes to the functional form of the regression equation. In Figure 13, we divide through equation (3) by the average expenditure share for each product category. The logic for doing this is to reduce potential heteroskedasticity in the baseline specification. In the baseline specification, the dependent variable is the level of the expenditure share. The average level of the expenditure share varies quite a bit across products—e.g., it is much higher for food/total than for fruit/food. This much larger level of the expenditure share for some products than others may be associated with a larger variance of the error term for those products. Dividing through by the average expenditure share will then puts less weight on the product categories with large product shares.[10] It is clear from Figure 13 that once the baseline specification is scaled in this way, it yields results that are closer to the results for the specification that pools only the subcategories of food. However, since both food/total and the subcategories of food yield similar results, this scaling affects our results in only a modest way and, in particular, does not change the results qualitatively.

In Figure 14, we change the dependent variable in equation (3) from the level of the expenditure share to the logarithm of the expenditure share. From an economic standpoint, this means that we are assuming a different functional form for the underlying demand system. An advantage of this specification from a theoretical point of view is that the expenditure share is constrained to be positive. From an econometric standpoint, the effect of this change is similar to the rescaling in Figure 13 in that it effectively puts more weight on the product categories with smaller average absolute levels of expenditure shares. Again the results are not much affected.

An additional concern is that the shape of the Engel curve may have changed over time. Perhaps, for example, Engel curves have become flatter as China has developed, leading our model to be misspecified. Figure 15 compares the results of our baseline analysis to results based on estimating separate Engel curves for the pre-2002 and post-2002 periods. The figure shows that this modification has almost no impact on our results.

Table 2 compares our estimates of the income and price elasticities implied by the food Engel curve across different estimation approaches.[11] The first data column (Panel A) presents the results

[10] This specification is a simple Generalized Least Squares regression under the assumption that the variance of the error term varies by product category and is proportional to the average level of the product category's expenditures share.

[11] The formula for the expenditure elasticity in the linear-log case is $1 + \beta^k/\omega^k$, while the corresponding price elasticity formula is $-1 + (\gamma^k - \hat{\psi}^k \beta^k)/\omega^k$, where ω^k is the average of the national expenditure share for product

of estimating equation (3) using the regional data on food expenditure shares that we use in our baseline analysis. The estimated income elasticity for this specification implies that a 1% increase in real total expenditure is associated with a 0.65% relative increase in food purchases, all else equal. Costa (2001) and Tobin (1950) report similar values of the income elasticity of food for the US, while Hamilton (2001) reports a substantially lower value. The food price elasticity of -0.51, indicates that food is inelastically demanded.

The second data column of Table 2 presents elasticity estimates based on estimating equation (3) using income group data as opposed to province-level data. The income group data consist of prices and consumption of different commodities for 8 different income groups over time.[12] The price elasticity is not well identified in this specification (we do not observe separate price indexes for the different income groups); hence, we set the coefficient on the price term in this specification equal to its counterpart from the province level analysis. The income group estimation yields a very similar estimate of the expenditure elasticity—0.71—to our baseline specification.

The third data column of Table 2 reports estimates of the expenditure and price elasticities based on estimating equation using microdata from the 1995 and 2002 waves of the China Household Income Project (CHIP). To estimate equation (3), we merged the CHIP data with the regional price data that we use in our baseline analysis. The CHIP expenditure and price elasticities for food are 0.66 and -0.45 respectively, again very similar to our baseline estimates.[13]

Panel B of Table 2 presents estimates of the food Engel curve for the log-log specification of equation (3) where the dependent variable $\omega_{i,t}^k$ is the logarithm rather than the level of the expenditure share—the specification used in Figure 14. For all three estimation approaches we consider, this "log-log" specification yields very similar estimates of the expenditure and price elasticities to our baseline "linear-log" analysis.

Finally, let us compare our baseline inflation bias estimates, based on aggregated data for Chinese provinces, to estimates using the income group and CHIP data described above. Our estimates of the bias using the CHIP data are based on the food Engel curve alone, since only food consumption is available in the CHIP data. Comparing our baseline model's implications to

k over the 1995-2010 period. In the log-log case, the expenditure elasticity is given simply by β^k while the price elasticity is given by $-1 + \gamma^k - \hat{\psi}^k \beta^k$.

[12]The income groups are: poor, low income, lower middle income, middle income, upper middle income, high income and highest income.

[13]Filho and Chamon (2007) find that the Engel curve shift is larger for poor than rich households in the CHIP micro-data, and conclude this implies a larger inflation bias for poor households. We focus on regional averages as opposed to incomes and expenditure shares for individual households. The differences they observe across income groups appear small for our regional analysis, probably because our Engel curves are estimated over a much smaller range of incomes than in Filho and Chamon's analysis.

those of the CHIP model, we find that both specifications yield a large cumulative upward bias in the CPI over the 1995-2002 period: our baseline specification yields an average upward bias of 4% while the CHIP data yields an average upward bias of 6% over this period. Our estimates based on the income group data also have qualitatively similar results to our baseline analysis.[14]

6 The Hog Cycle of 2007

Our revised estimates of Chinese growth and inflation suggest a substantial slowdown in consumption growth in 2007. The decline in consumption growth coincides with a large spike in inflation. What is behind this pattern? Figure 16 depicts overall inflation alongside the inflation rate for food, non-food and meat. The figure shows that the 2007 inflation spike was driven primarily by an increase in food prices and that within food, meat inflation was particularly high.

The increase in meat prices was, in turn, driven largely by an increase in the price of pork. Figure 17 depicts the hog price cycle since 1995. The dark line depicts the change in the wholesale price of hogs (the price the slaughterhouse pays to farmers) while the lighter line depicts the change in Chinese pork production. Since 1995, there have been numerous hog price cycles. The figure shows a sharp decline in pork production and a sharp increase in hog prices in 2007.

These symptoms of a supply shock in the hog market are corroborated by widespread accounts of a serious infestation of "blue ear disease." In 2007, "blue ear disease" was observed in 26 of 33 Chinese provinces. The disease and ensuing panic among Chinese pork farmers was associated with a substantial decrease in the supply of pork, as household pig farmers, who provide more than 50% of Chinese meat, left the market in large numbers. The *New York Times* reported that, "International health experts are already calling this one of the worst disease outbreaks ever to hit Asia's livestock industry....Officials in Beijing worry that widespread pork shortages and soaring food prices could prompt panic, unrest or inflation, undermining a sizzling economy" (Barboza, 2007). The importance of these supply-side factors in explaining the 2007 price spike is consistent with the results of our Engel curve analysis—that high inflation during this period led to low consumption growth.

Another piece of suggestive evidence that 2007 was, in fact, a time of slow (and even negative)

[14] Both the income group analysis and the analysis based on CHIP micro-data yield larger positive biases in official inflation in the late 1990's than our baseline approach. This is consistent with the finding in Filho and Chamon (2007) that the estimated biases are larger for poorer households. Poor households have a greater effective weight in both the CHIP and income-group based analysis since they account for a significant fraction of households, but a small fraction of consumption at the regional level. In this sense, our estimates based on regional data are conservative.

Chinese consumption growth comes from government subsidy programs. The Minimum Living Standard Allowance (MLSA) is a government subsidy program that has been in operation on a national scale since 1997. Over this time period, the Ministry of Civil Affiars has made five announcements in which it discusses increasing the MLSA. Four of these five announcements were in 2007 and 2008. Three of the announcements made specific recommendations to increase the MLSA by a combined total of RMB 40—a significant increase relative to the previous level of roughly RMB 170. The announcements stated that these increases were intended to offset increasing food prices.[15] Similarly, the Ministry of Civil Affairs announced on July 4, 2007 that local governments should establish or improve their "Temporary Relief" programs, which are intended to provide support to low-income families suffering temporary economic difficulties.[16] The number of people receiving "Temporary Relief" rose sharply in 2007, in line with this announcement.[17]

7 Conclusion

We use an Engel curve approach to derive new estimates of Chinese growth and inflation. This approach makes use of systematic discrepancies between cross-sectional and time-series Engel curves in China. Our Engel-curve based estimates of inflation are highly correlated with official statistics, but suggest that official statistics present a smoothed version of reality. Our Engel-curve based estimates yield even lower inflation than official statistics in the low inflation 1990's, but a reversal of the bias and substantially higher inflation in the 2000's. These qualitative patterns emerge consistently when we apply our Engel curve methodology to wide variety of expenditure categories—major categories like food and clothing as well as subcategories such as grain, eating-out, and garments—and survive numerous robustness checks, buttressing the case that they reflect systematic mismeasurement of official statistics.

[15] On August 14, 2007, the government announced that the subsidies would be increased by at least RMB 15 per person per month for urban residents, and on September 24 2007 the government announced that the subsidies would be increased by another RMB 10 per person per month for the next three months. On February 4, 2008, the government announced that the 2007 increases in subsidies still applied in 2008, and that as of January 1, 2008, there would be an additional RMB 15 increase in the urban MLSA and a RMB 10 increase in the rural MLSA. The remaining two announcements were less specific. On June 14, 2007, the government noted that local governments should continue to focus on making appropriate increases in the urban minimum living subsidy level. On November 12, 2001, the government announced that local governments at all levels should continue to focus on making appropriate increases in the MLSA. These announcements were obtained from the official website of the Ministry of Civil affairs http://dbs.mca.gov.cn/article/csdb/.

[16] Since 1992, there has been only one other announcement regarding the "Temporary Relief Program" by the Ministry of Civil Affairs. The other announcement followed the 2008 earthquake in Sichuan province, which killed 70 thousand people.

[17] Statistics on the number of people receiving "Temporary Relief" are available from the main statistical yearbook of the Chinese National Bureau of Statistics.

Our bias-adjusted estimates imply that urban consumption growth was far lower than official statistics indicate in the late 2000's and dipped briefly into negative territory in 2007 and 2008. The idea that this period was one of low consumption growth is consistent with the Chinese government's unusual decision in increase subsidies to the poor in 2007 and 2008 to offset the rising cost of food. Ample evidence points to a supply shock as a major driver of the rising cost of food. A severe outbreak of the "blue ear disease" among Chinese hogs led to a dramatic increase in the price of pork, and a substantial decrease in pork production.

One interpretation of the biases we estimate is that they reflect the Chinese government's desire to report smooth inflation and growth statistics. Alternatively, these patterns may reflect more general measurement problems in GDP construction that lead price indexes to be too smooth. Nakamura and Steinsson (2012) show that rapid product turnover can generate a "product replacement bias" associated with price changes that occur at the time of product replacements being dropped that leads aggregate price indexes to be too smooth.

Earlier studies by Hamilton (2001) and Costa (2001) have used an Engel curve approach to construct alternative measures of U.S. growth and inflation. We have analyzed the resulting growth and inflation series and, in contrast to our findings about China, these series do not appear to exhibit "excess smoothness" of growth and inflation for the United States. Rather, they find that official statistics overstate inflation and understate growth. They interpret their findings as evidence for new goods bias. The high growth rates we estimate in the late 1990s for China may be evidence of new goods bias for China. However, the overall pattern of results we find for China is more intricate.

A Data Appendix

Our primary source of data for the years 2005-2011 is the "China Urban Life and Price Yearbook," published by the Chinese National Bureau of Statistics (NBS). For 1995-2004, we use the previous version of this yearbook, known as the "Chinese Price and Urban Household Survey Yearbook."[18] From these yearbooks, we obtain the following variables at both the regional and income-group levels: commodity prices (CPI and RPI, at the regional level only), household expenditures by commodity, household size, the number of people earning income (including non-wage income such as retirement earnings) per household, and the number of people employed per household.

Our second source of data is the "China Statistical Yearbook," also published by the NBS, from which we obtain the following variables at the regional level: sex ratio, elderly dependency ratio, child dependency ratio, and unemployment rate.[19] Household survey also has data on sex ratio. However, 2006 data on sex ratio are missing in the survey. We use instead general sex ratio from the main statistical yearbook as a proxy. General sex ratio includes individuals who do not belong to a household.

We made a number of adjustments and modifications to the raw data to eliminate inconsistencies and errors, and to harmonize the expenditure categories across years.

1. The NBS revised the survey yearbook in 2002 and 2007, resulting in some inconsistencies in the definitions of commodities. First, the categories "Fruits, Melons and their Products" and a"Nuts and Kernels" are separate categories in the 1995-2001 data; however, "Nuts and Kernels" becomes a subcategory of "Fruits, Melons and their Products" in 2002. Thus, the definition of "Fruits, Melons and their Products" is inconsistent before versus after 2002. To address this issue, we combine the categories "Nuts and Kernels" and "Fruits, Melons and their Products" for the period before 2002, which harmonizes the definitions over time. This newly defined "Fruits, Melons and their Products" is the "Fruit" category we use in our pooling regressions.

   Second, we combine the "Meat" and "Poultry" categories in the 2002-2011 data to create a larger category consistent with the "Meat and Poultry" category before 2002. This newly defined "Meat and Poultry" category is the "Meat" category we use in our pooling regressions.

[18] Most of these data are available in Chinese in digital form from the China Knowledge Resource Integrated Database (CNKI) database.

[19] These data are available in digital form from the website of NBS at http://www.stats.gov.cn/english/statisticaldata/yearlydata/.

2. We corrected a number of errors in the raw data. In 1995 and 1996, the sub-categories of "Food" do not add up to "Food." Moreover, the "Other Foods" category has a value of zero for all regions in these two years only. We therefore believe that the "Other Foods" expenditures are misreported in these years. We define "Other Foods" in these two years as equal to the gap between "Food" and the sum of all its subcategories.

3. In 2006, the price observations from the household yearbook for Beijing, Tianjin, Shanghai, and Chongqing are all zero for all goods. We are able to partially fill in these missing data by using the fact that, when available, observations of the urban and national CPI are the same for these regions, and the national CPI is also available from the main Statistical Yearbook. We therefore substitute national CPI data from the main Statistical Yearbook for these missing values whenever possible. Unfortunately, some missing values remain since the main Statistical Yearbook reports the CPI for a less detailed array of categories than the household survey. In particular, price observations for Starch, Bean, Condiment, Sugar, Milk, Cake are missing in 2006. This means that our pooling estimation for 2006 does not incorporate information from these subcategories of food.

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Table 1
Coefficients from Baseline Pooled Specification

	Average Share	Income (β^k)	Price (γ^k)
Food	0.40	-0.131	0.117
		(0.005)	(0.007)
Grain	0.10	-0.051	0.092
		(0.003)	(0.006)
Meat	0.21	-0.040	0.083
		(0.003)	(0.005)
Bean	0.01	-0.005	0.004
		(0.002)	(0.004)
Starch	0.01	-0.004	-0.002
		(0.003)	(0.003)
Egg	0.03	-0.012	0.008
		(0.003)	(0.004)
Oil	0.03	-0.004	0.027
		(0.003)	(0.004)
Milk	0.04	0.021	0.023
		(0.003)	(0.003)
Baked Goods	0.02	-0.001	0.003
		(0.002)	(0.003)
Condiments	0.01	-0.002	0.004
		(0.002)	(0.003)
Sugar	0.01	0.001	0.004
		(0.003)	(0.004)
Vegetable	0.10	-0.026	0.033
		(0.002)	(0.005)
Fruit	0.07	0.004	0.021
		(0.002)	(0.005)
Fish	0.07	-0.010	0.001
		(0.002)	(0.006)
Eating Out	0.17	0.111	0.003
		(0.004)	(0.008)

The table reports the coefficients on total expenditure and relative prices from equation (3) in the paper for our baseline specification. Our baseline specification pools information from the Engel curve for food expenditures as a fraction total expenditures with 14 separate Engel curves for expenditures on 14 subcategories of food (e.g., grain, mean or eating out) as a fraction of food expenditures. Standard errors are reported in parentheses.

Table 2
Income and Price Elasticities for Food Expenditures

	Regional Analysis	Income Group Analysis	Household Survey
Panel A: Linear-Log			
Income Elasticity	0.65	0.71	0.657
	(0.011)	(0.01)	(0.00)
Price Elasticity	-0.51		-0.454
	(0.034)		(0.08)
Panel B: Log-Log			
Income Elasticity	0.61	0.71	0.577
	(0.026)	(0.0027)	(0.00)
Price Elasticity	-0.54		-0.326
	(0.079)		(0.19)

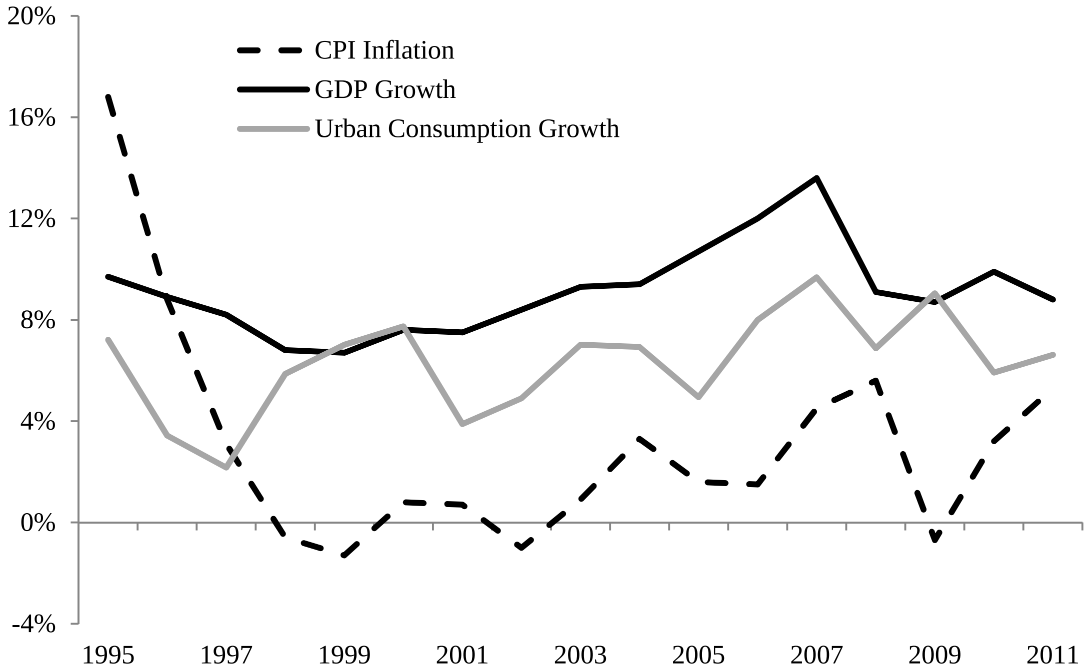


Figure 1: Official Growth and Inflation in China

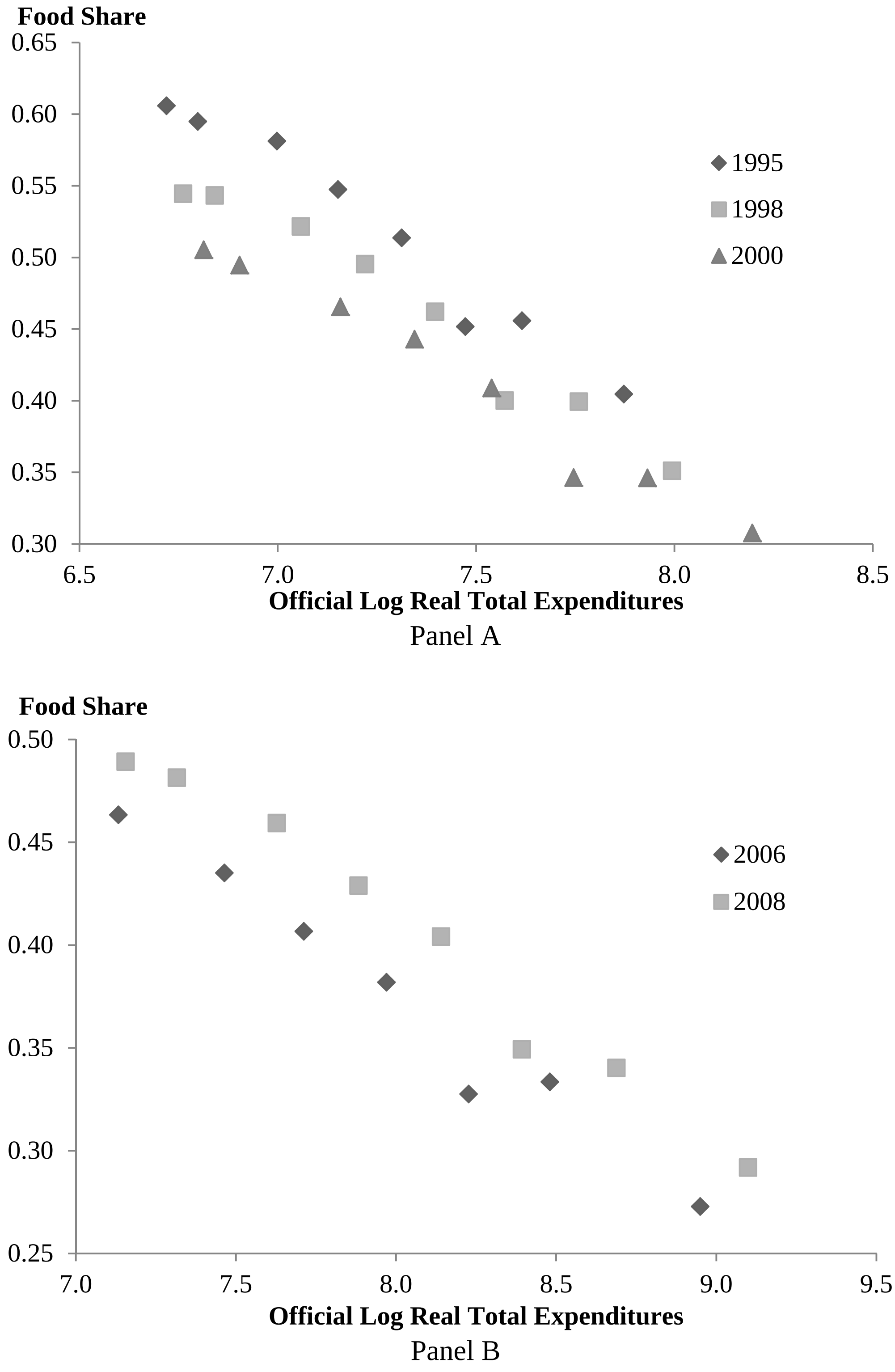


Figure 2: Income Group Engel Curves

The figure plots the expenditure share on food for 8 different income groups in China for various years. The reported food shares are adjusted for income group fixed effects (we add back the fixed effect for the second highest income group) and movements in the relative price of food using an estimate for the price elasticity of food from our baseline regional specification from section 5. Real Total Expenditures are measured in 1985 dollars.

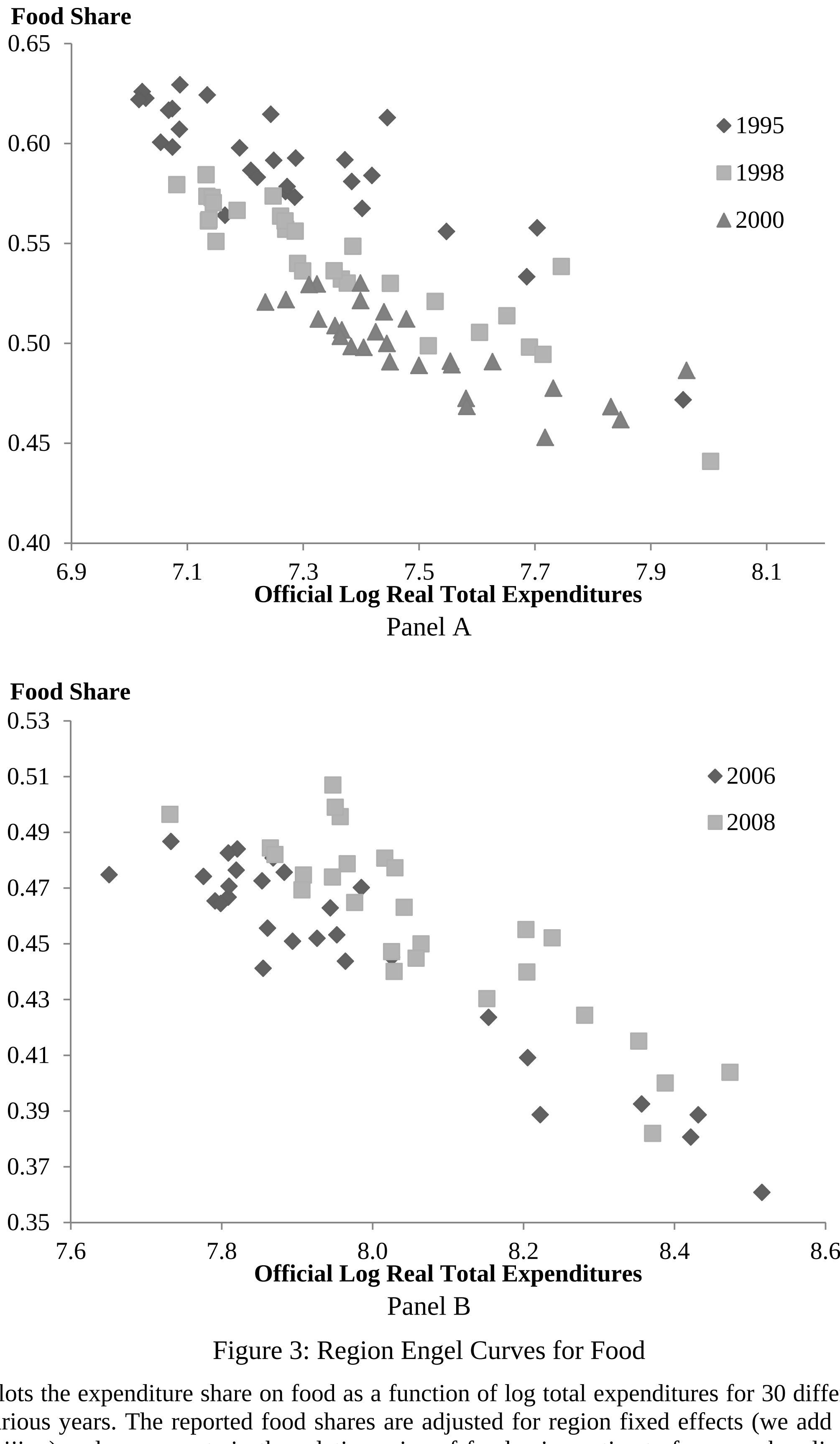
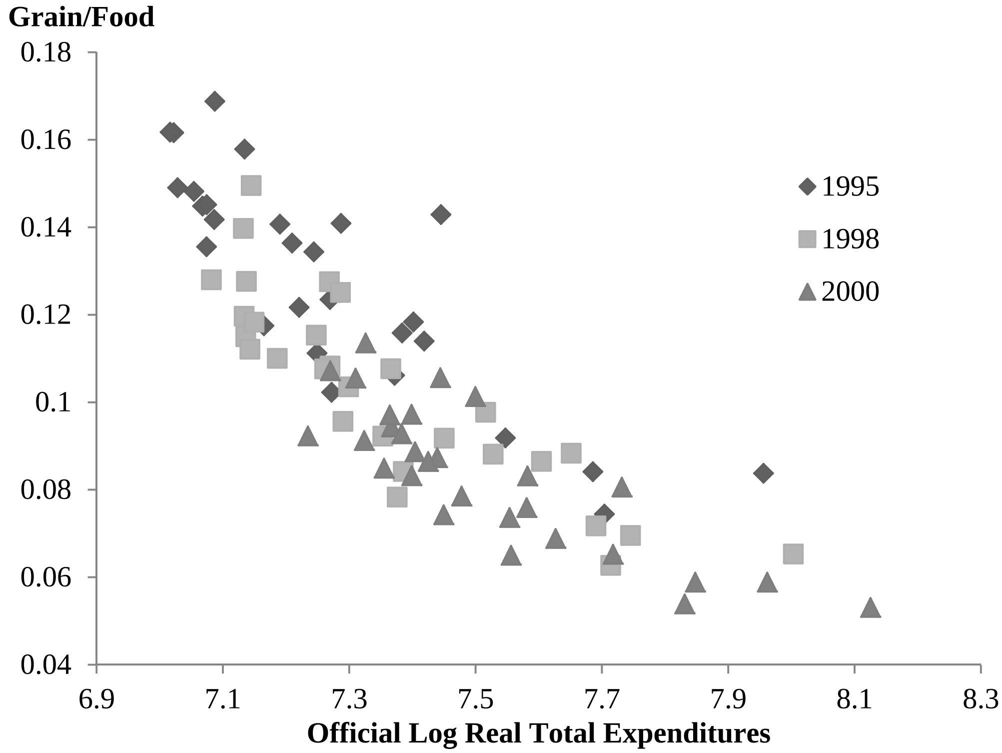
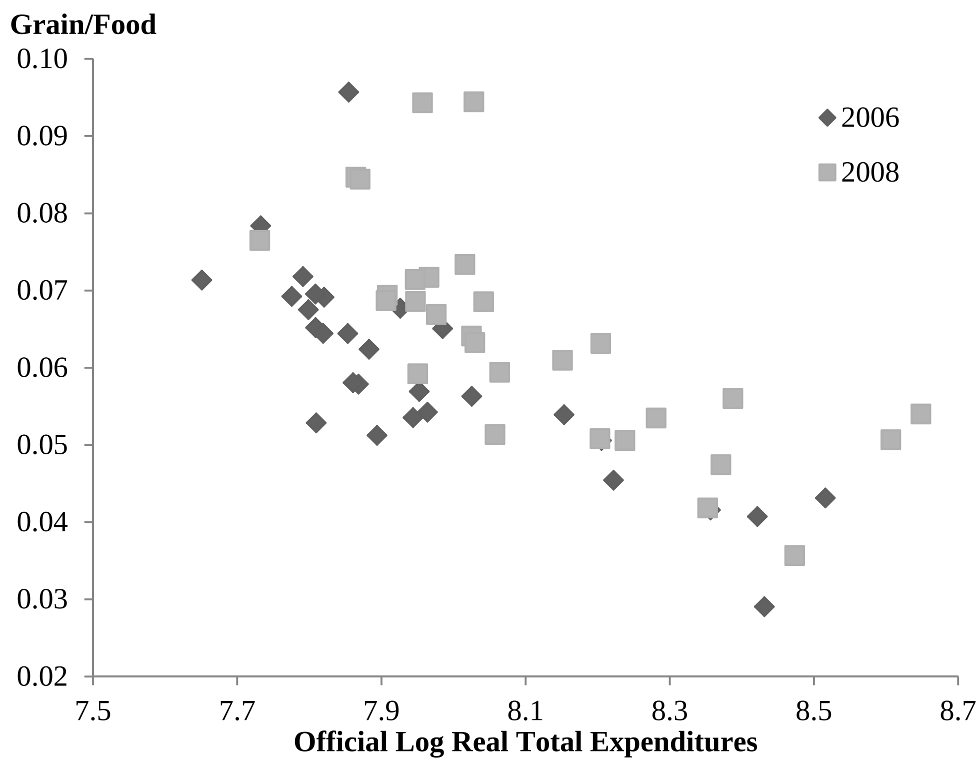


Figure 3: Region Engel Curves for Food

The figure plots the expenditure share on food as a function of log total expenditures for 30 different regions in China for various years. The reported food shares are adjusted for region fixed effects (we add back the fixed effect for Beijing) and movements in the relative price of food using estimate from our baseline specification from section 5. Real Total Expenditures are measured in 1985 dollars.



Panel A



Panel B

Figure 4: Region Engel Curves for Grain

The figure plots expenditures on grain as a fraction of expenditures on food as a function of log total expenditures for 30 different regions in China for various years. The reported grain/food shares are adjusted for region fixed effects (we add back the fixed effect for Beijing) and movements in the relative price of grain using estimate from our baseline specification from section 5. Real Total Expenditures are measured in 1985 dollars.

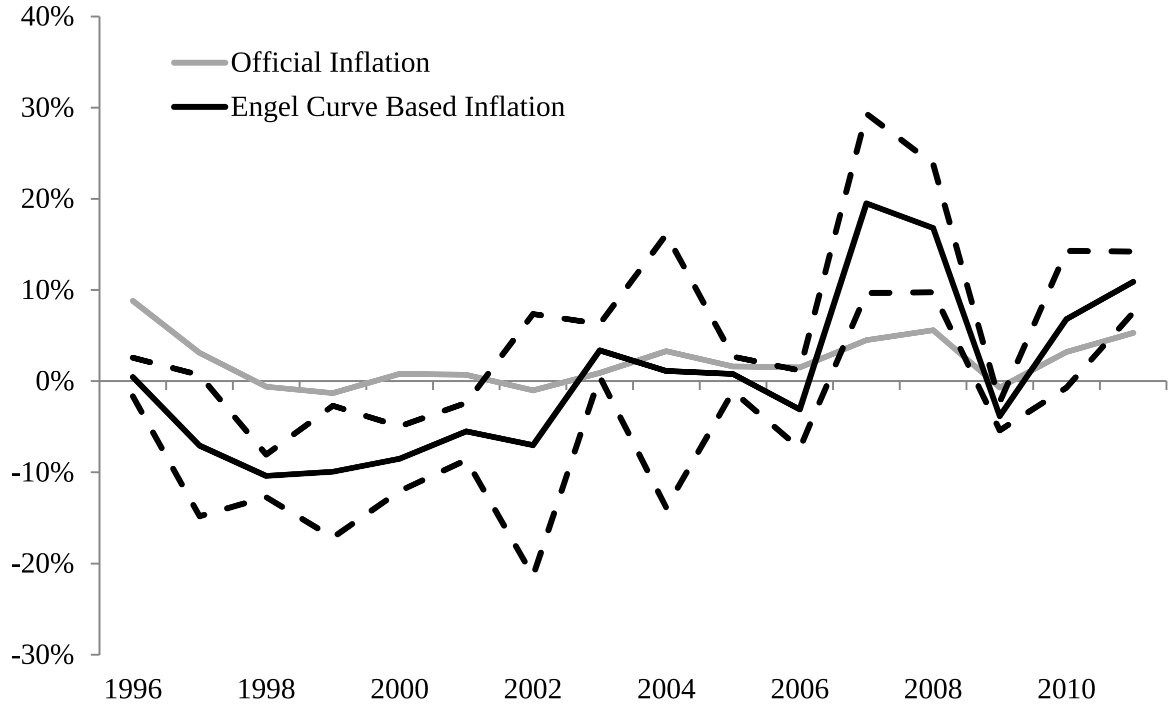


Figure 5: Official and Engel Curve Based Inflation

Note: Official inflation is the Chinese CPI. Adjusted inflation is from a pooled specification using the Engel curve for food expenditures as a fraction of total expenditures and Engel curves for the expenditures on 14 major subcategories of food (e.g., grain, mean or eating out) as a fraction of food expenditures. Dashed lines are two standard error bands. Standard errors are clustered by commodity.

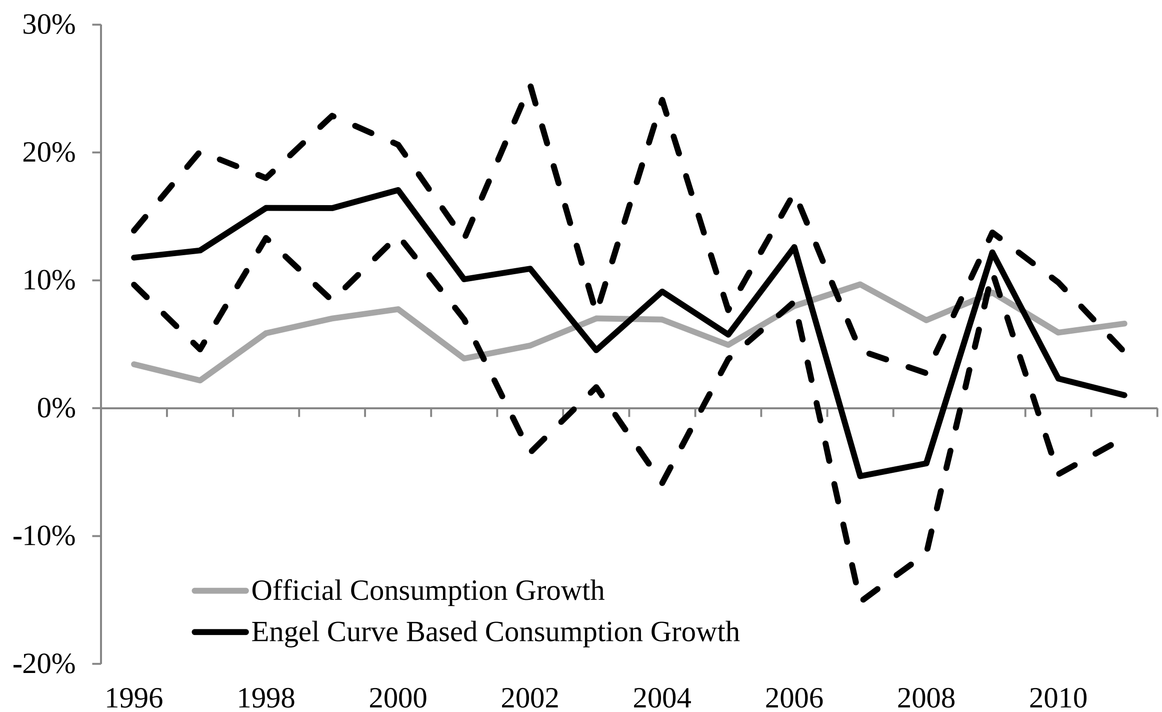


Figure 6: Official and Engel Curve Based Urban Consumption Growth

Note: Adjusted urban consumption growth is from a pooled specification using the Engel curve for food expenditures as a fraction of total expenditures and Engel curves for the expenditures on 14 major subcategories of food (e.g., grain, mean or eating out) as a fraction of food expenditures. Official consumption growth is for urban consumption from the National Accounts. Dashed lines are two standard error bands. Standard errors are clustered by commodity.

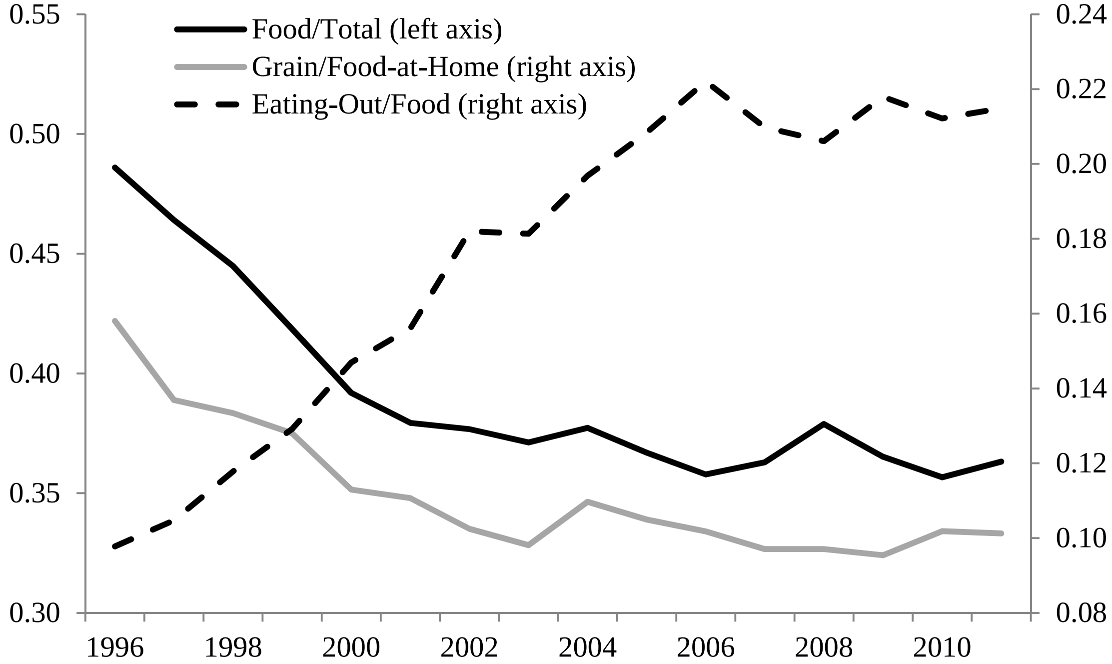


Figure 7: Evolution of Expenditure Share for Food, Grain, and Eating Out

The figure plots the evolution over time of the share of total expenditures that go towards food, the share of food-at-home expenditures that go towards grain, and the share of food expenditures that go toward eating out.

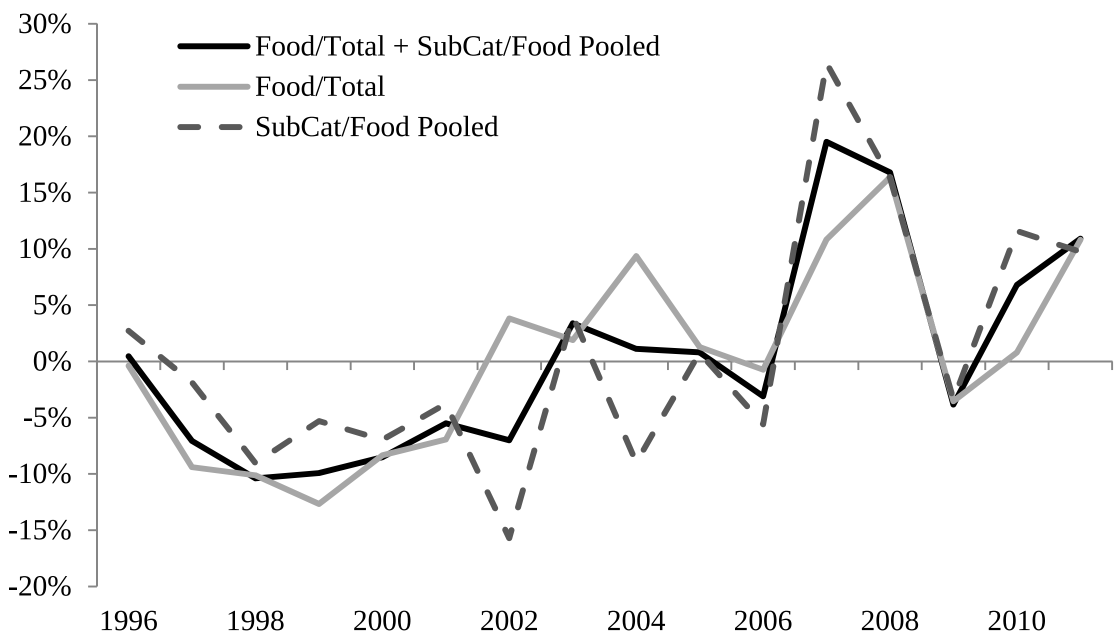


Figure 8: Food versus Subcategories of Food

The figure plots results based on three specifications. The first is the baseline specification that pools the Engel curve for food expenditures as a fraction of total expenditures and Engel curves for the expenditures on 14 major subcategories of food as a fraction of food expenditures. The second specification is for the Engel curve for food expenditures only. The third specification pools the Engel curves for the expenditures on the 14 major subcategories of food as a fraction of food expenditures only.

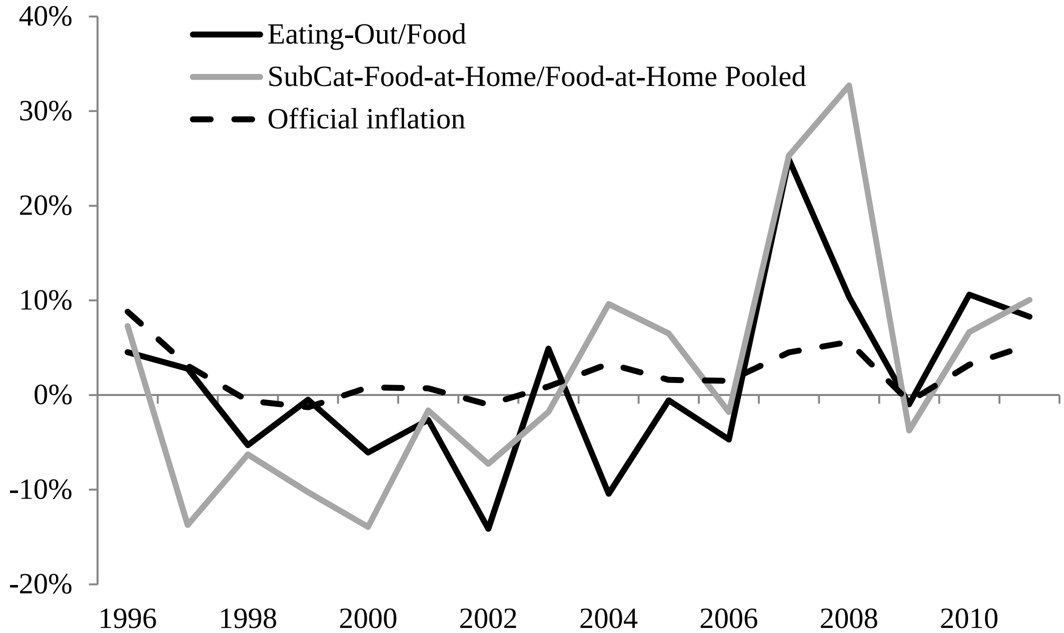


Figure 9: Eating Out versus Subcategories of Food-at-Home

The figure plots official inflation along with two Engel curve based estimates of inflation. The dark line is an estimate of inflation based on the Engel curve for expenditures on eating out relative to food, while the lighter line is an estimate of inflation based on a specification that pools 13 Engel curves for expenditures on 13 subcategories of food relative to total expenditures on food at home.

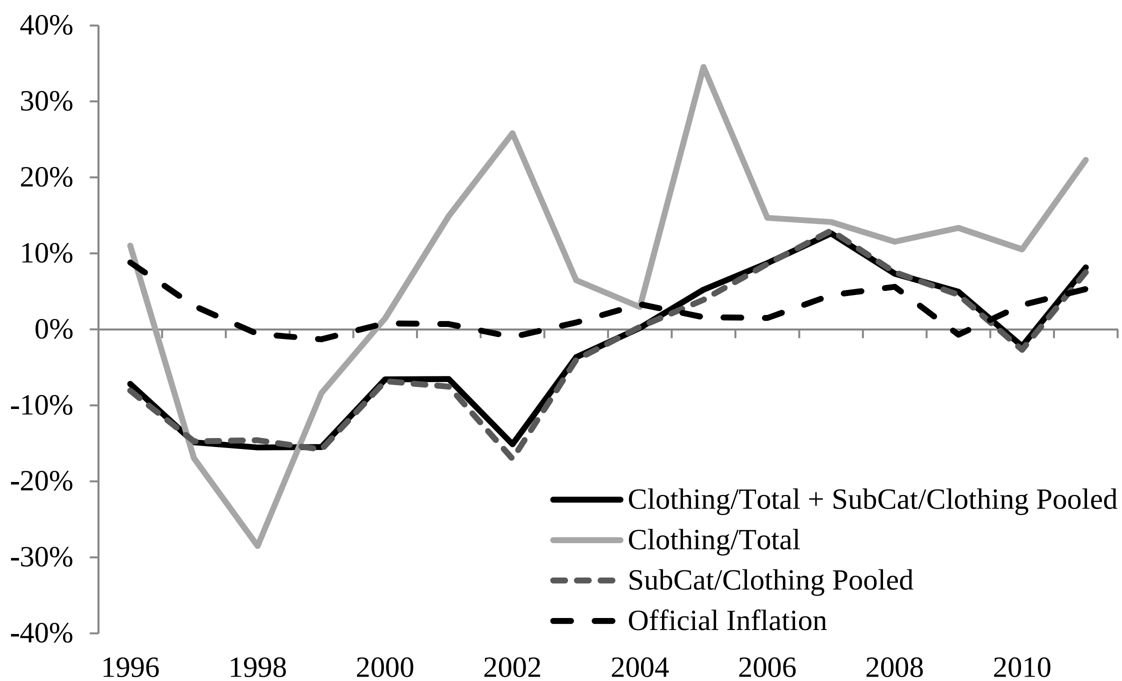


Figure 10: Clothing and Subcategories of Clothing

The figure plots official inflation along with three Engel curve based estimates of inflation. The unbroken dark line is an estimate of inflation based on a specification that pools the Engel curves for clothing expenditures as a fraction of total expenditures and Engel curves for all subcategories of clothing. The unbroken light line is based on the Engel curve for the clothing share alone, while the dark gray dotted line is based on a pooled specification of the subcategories of clothing alone.

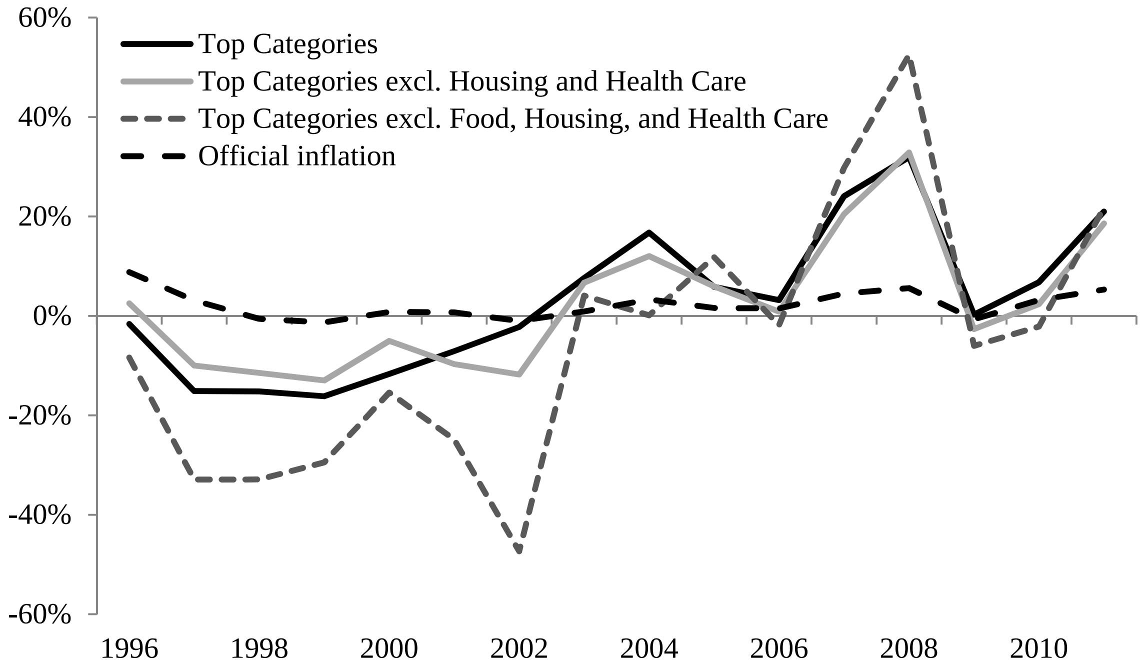


Figure 11: Top Categories

The figure plots official inflation along with three Engel curve based estimates of inflation. The unbroken dark line is based on a specification that pools the Engel curves for the expenditure share of all top categories. The unbroken light line is the same except that it excludes housing and education. The dark gray broken line is the same expect that it also excludes food.

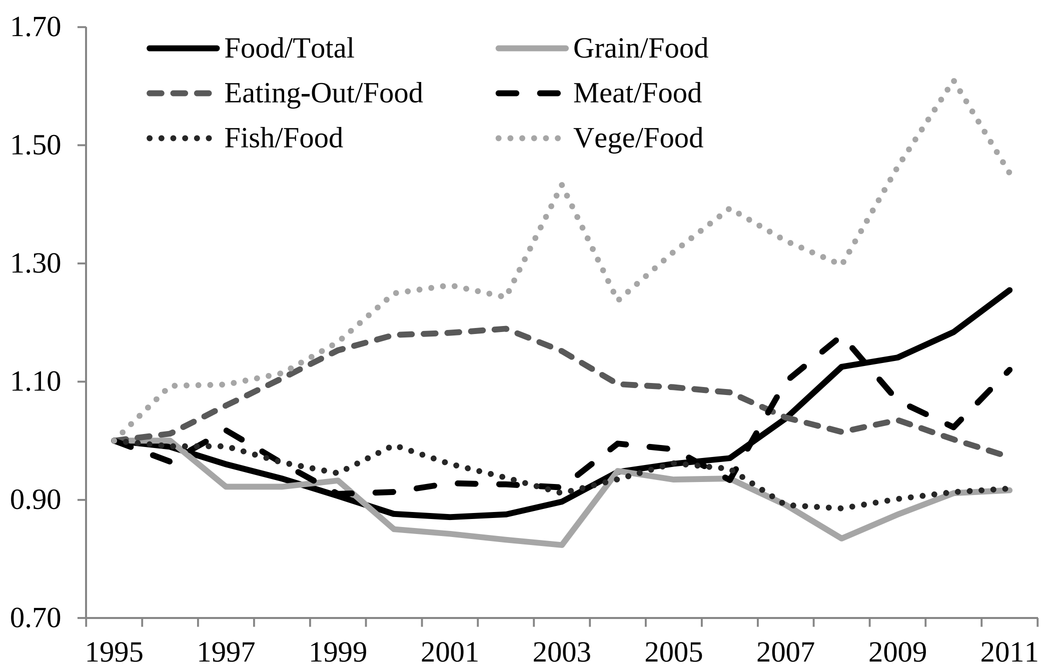


Figure 12: Relative Prices

The figure plots the price of food relative to total expenditure, the price of grain, eating out, meat, fish and vegetables relative to food. All series are normalized to 1 in 1995.

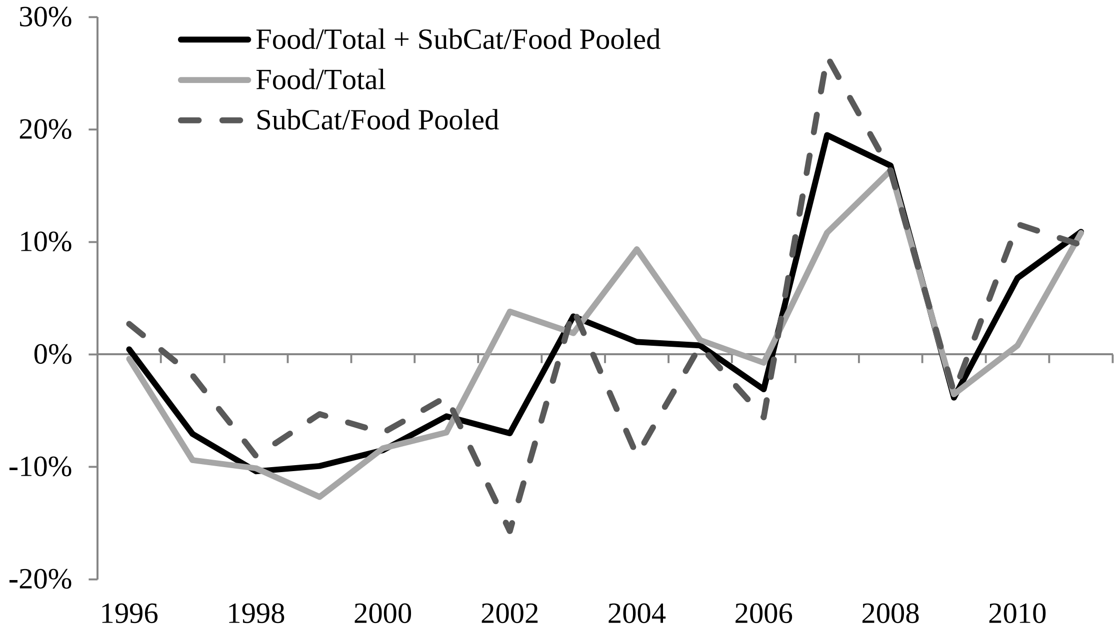


Figure 13: Food versus Subcategories of Food Scaled

The figure plots results based on three specifications. The first is the baseline specification that pools the Engel curve for food expenditures as a fraction of total expenditures and Engel curves for the expenditures on 14 major subcategories of food as a fraction of food expenditures. The second specification is for the Engel curve for food expenditures only. The third specification pools the Engel curves for the expenditures on the 14 major subcategories of food as a fraction of food expenditures only. In the pooled specifications, the Engel curves are scaled by the average expenditure share for the product in question to reduce heteroskedasticity.

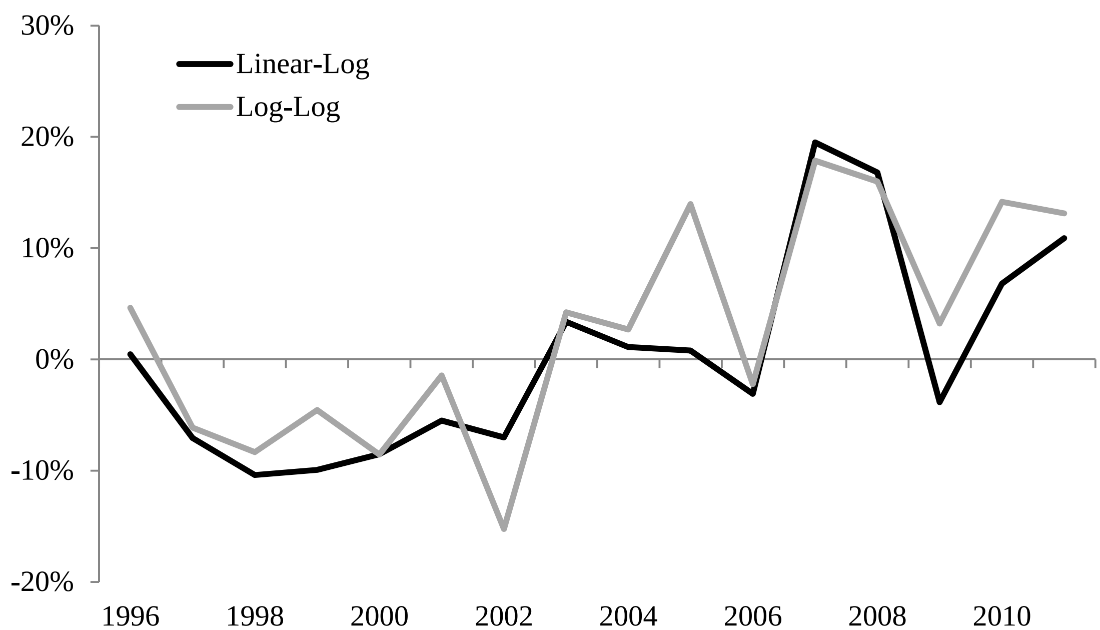


Figure 14: Linear-Log versus Log-Log Specification

The figure plots results based on our baseline specification and an alternative version of this specification where the dependent variable is the log of the expenditure share as opposed to the level of the expenditure share. In both cases the results are based on a specification that pools the Engel curve for food expenditures as a fraction of total expenditures and Engel curves for the expenditures on 14 major subcategories of food as a fraction of food expenditures.

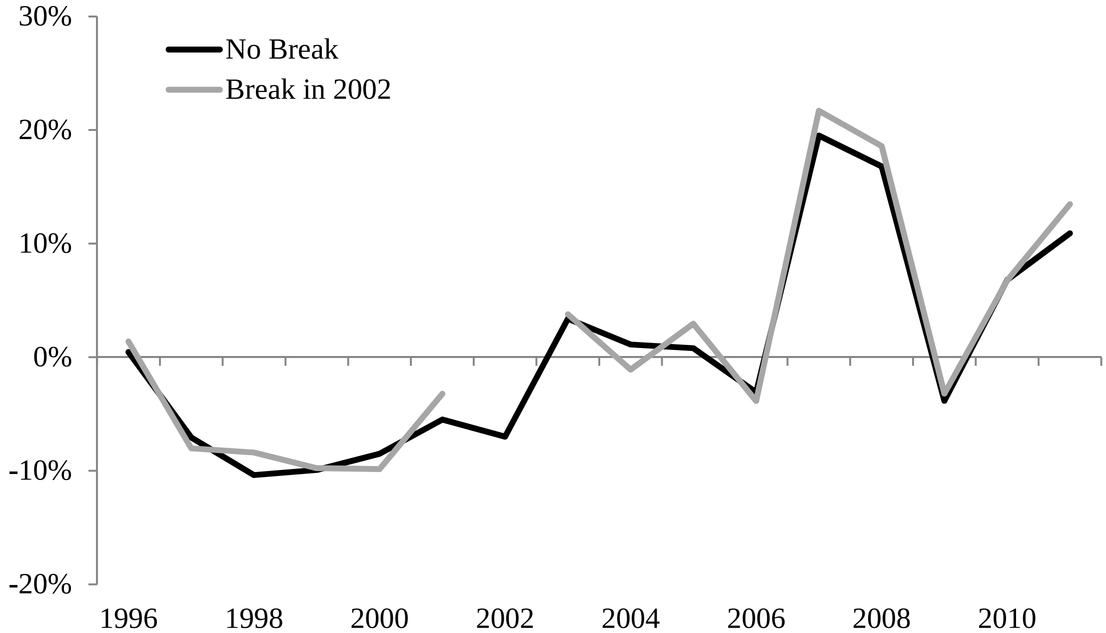


Figure 15: Separate Engel Curves Pre and Post 2002

The figure plots results based on our baseline specification and an alternative version of this specification where we allow the Engel curve coefficients to be different before and after 2002. In both cases the results are based on a specification that pools the Engel curve for food expenditures as a fraction of total expenditures and Engel curves for the expenditures on 14 major subcategories of food as a fraction of food expenditures.

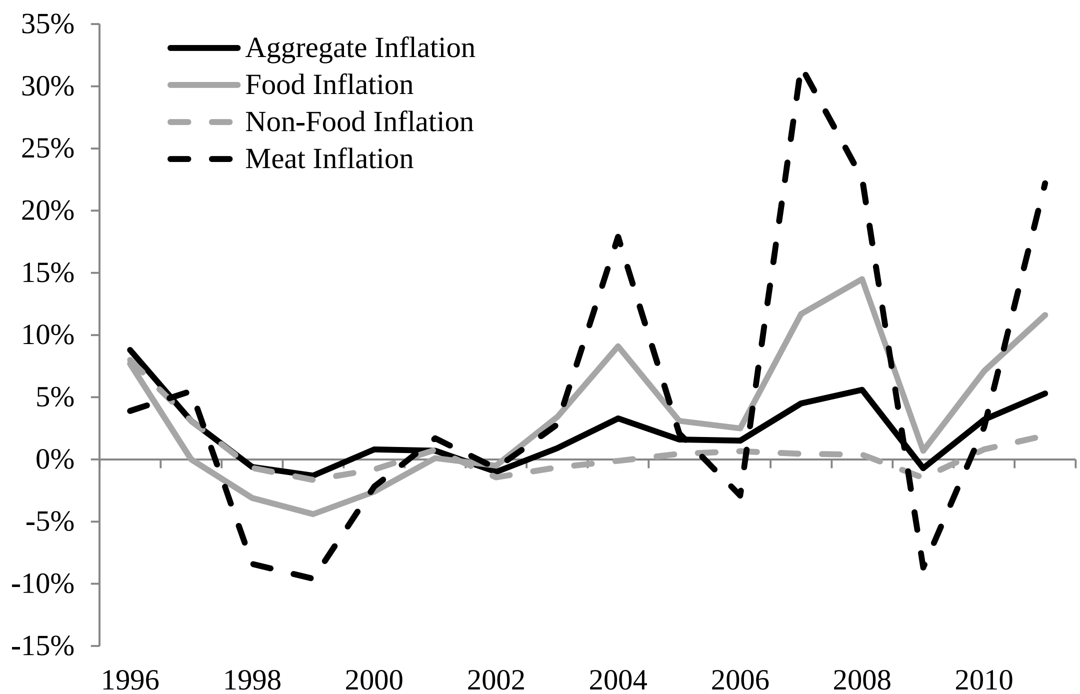


Figure 16: Food and Meat Inflation

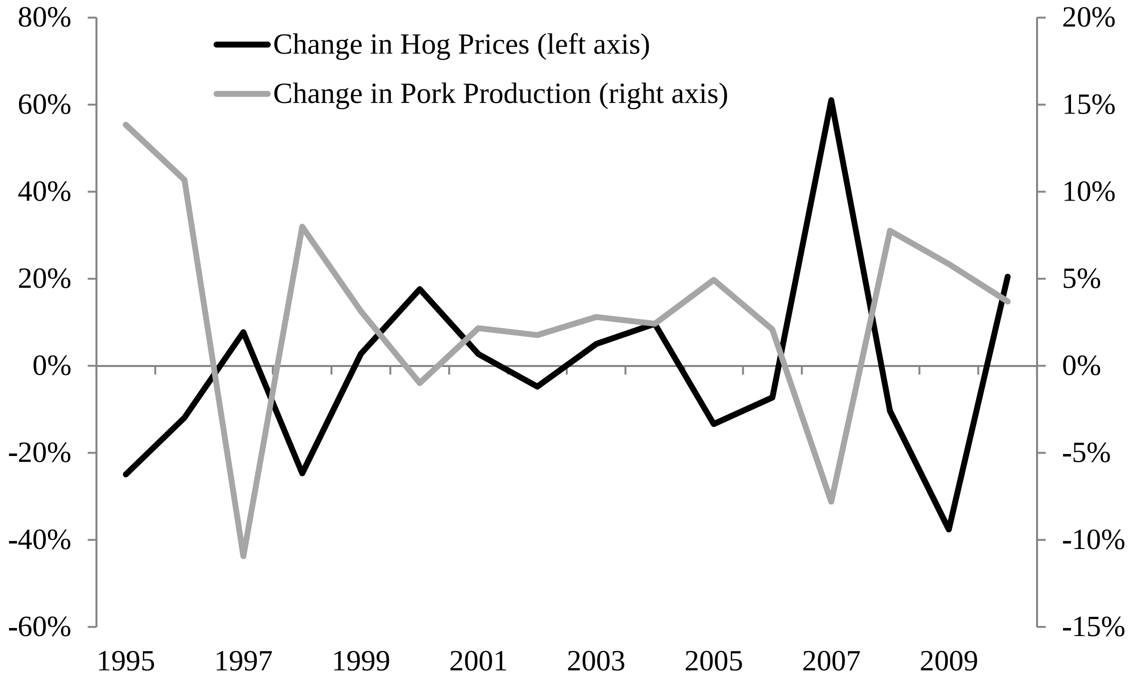


Figure 17: Changes in Prices and Production of Pork

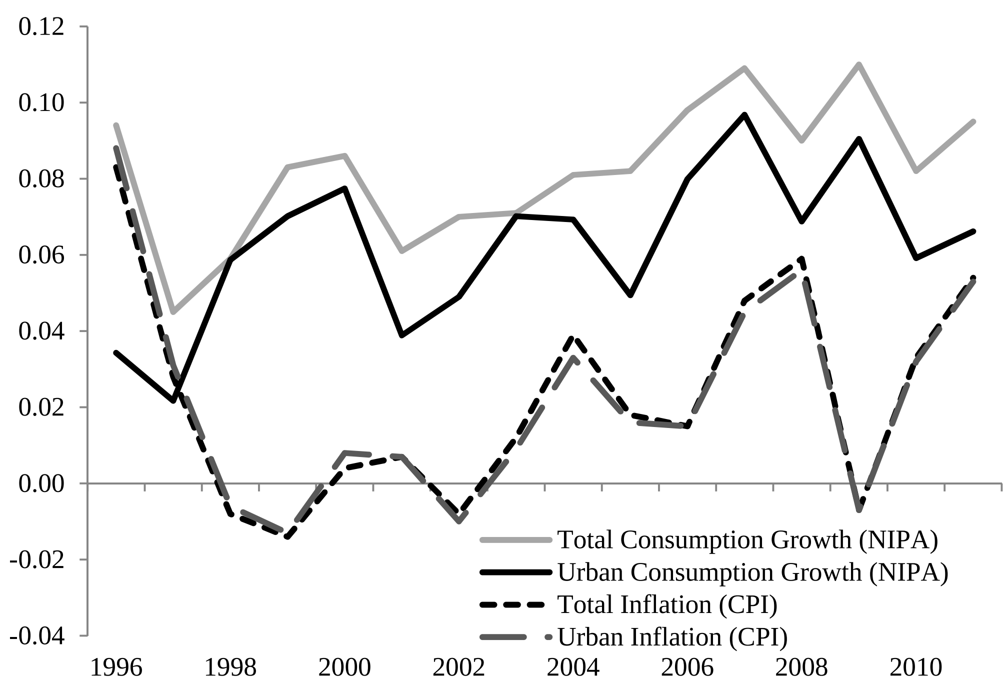


Figure A.1: Official Inflation and Real Consumption: Urban vs. Total

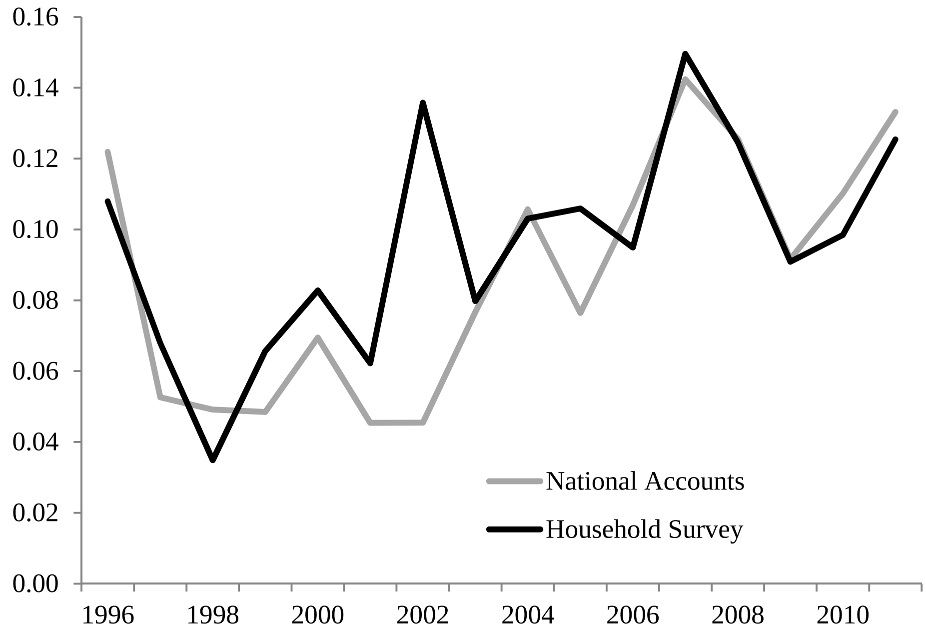


Figure A.2: Nominal Consumption: National Accounts vs. Household Survey