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Inflation Anchoring and Growth: Evidence from Sectoral Data

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Abstract

Central bankers often assert that low inflation and anchoring of inflation expectations are good for economic growth (Bernanke 2007, Plosser 2007). We test this claim using panel data on sectoral growth for 22 manufacturing industries for 36 advanced and emerging market economies over the period 1990-2014. Inflation anchoring in each country is measured as the response of inflation expectations to inflation surprises (Levin et al., 2004). We find that credit constrained industries—those characterized by high external financial dependence and R&D intensity and low asset tangibility—tend to grow faster in countries with well-anchored inflation expectations. The results are robust to controlling for the interaction between these characteristics and a broad set of macroeconomic variables over the sample period, such as financial development, inflation, the size of government, overall economic growth, monetary policy counter-cyclicality and the level of inflation. Importantly, the results suggest that it is inflation anchoring and not the level of inflation *per se* that has a significant effect on average industry growth. Finally, the results are robust to IV techniques, using as instruments indicators of monetary policy transparency and independence.

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Keywords: industry-level data, inflation anchoring, medium-term growth, credit constraints

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"*The extent to which inflation expectations are anchored has first-order implications for the performance … of the economy*" (Bernanke, July 10, 2007)

"*To the extent that a monetary authority can build a reputation and gain credibility for low inflation, it … produces tangible economic benefits*" (Plosser, April 10, 2007)

I. Introduction

Central bankers often assert that low and stable inflation fosters macroeconomic stability and growth. Keeping inflation anchored is said to reduce the uncertainty that firms and households face, allowing them to plan better for the future and carry out the longer-term investments that lead to higher growth. Former Fed Chair Paul Volcker stated that: *"Inflation feeds in part on itself, so part of the job of returning to a more stable and more productive economy must be to break the grip of inflationary expectations."* (Volcker, statement before the Joint Economic Committee of the U.S. Congress, October 17, 1979). The important role of inflation expectations has led many central banks around the world to improve transparency regarding the central bank's goals, often explicitly through the adoption of an inflation target (IT) and better communication with economic agents.

Several authors have tried to demonstrate the benefits of low inflation for growth empirically. For example, Fischer (1993) and Barro (1995) use cross-section and panel data for a large sample of countries to show that very high inflation was detrimental to growth, after controlling for other factors, over the period 1960 to 1990. However, other authors have found it difficult to demonstrate such impacts—particularly in more recent decades when inflation rates have been lower than in the 1970s and 1980s—or have found the evidence to be fragile. For instance, using an extreme bound analysis, Levine and Renelt (1992) concluded that inflation variables are not robustly correlated with growth. Judson and Orphanides (1999) conclude that "the empirical evidence documenting the benefits of low inflation is not very persuasive."

The main challenge in identifying causal effects of inflation on growth using aggregate data is that it is very difficult to control for all possible factors that could be correlated with inflation (or inflation volatility) and that at the same time may affect growth. This paper tries to overcome this limitation by using industry-level data and applying a difference-in-difference strategy à la Rajan and Zingales (1998). Our conjecture about which industries that should benefit more from inflation anchoring is motivated by recent work by Aghion et al. (2010). Their work suggests that volatility in the economic environment—caused by policies or shocks—is particularly harmful to growth for those firms and industries that are credit constrained as it pushes them toward shorter-term investments rather than longer-term investments that boost growth. Motivated by this, our framework examines the sectoral output growth effect of the interaction between a country's measure of inflation anchoring and sectoral-specific measures of credit constraints, after controlling for the unobserved country- and industry-specific characteristics. The framework is estimated for an unbalanced panel of 22 manufacturing industries for 36 advanced and emerging market economies over the period 1990-2014.

The advantages of adding a cross-industry dimension, compared to just a cross-country analysis, are twofold:

- First, the degree of inflation anchoring is captured by the sensitivity of inflation expectations to inflation surprises—a unique time-invariant parameter that varies only across countries. Thus, the country-fixed effect to control for unobserved cross-country heterogeneity in a standard cross-country analysis absorbs the country-specific inflation anchoring coefficient, which calls for a more disaggregated level of analysis.

- Second, it mitigates concerns about reverse causality. While it is difficult to identify causal effects using aggregate data, it is much more likely that inflation anchoring at the country level affects its industry-level outcomes than the other way around. Since we control for country fixed effects—and therefore for aggregate output—reverse causality in our setup would imply that differences in output across sectors influence inflation anchoring at the aggregate level—which seems implausible. Moreover, our main independent variable is the interaction between the degree of inflation anchoring and industry-specific technological characteristics obtained from the U.S. firm-level data, which makes it even less plausible that causality runs from industry-level growth to this composite variable.

The main finding of our paper is that inflation anchoring fosters growth in industries that are more credit constrained. Figure 1 summarizes this finding in an intuitive way. In Figure 1, we plot the average value added growth of each manufacturing industry from 1990 to 2014 against the sensitivity of (medium-term, that is, five-year ahead) inflation expectations in response to inflation surprises—our measure of inflation anchoring—estimated by each country by controlling for the initial share of each manufacturing industry. To be specific, we regress the average value added growth of an industry *i* in a country *c* on the measure of inflation anchoring, a set of industry dummies, and the initial share of the industry *i* in a country *c*. The left panel in Figure 1 plots this relationship only for industries with below-median levels of external financial dependence (i.e., less credit constrained industries); the right panel plots the relationship only for industries with above-median levels of external financial dependence (i.e., more credit constrained industries). It is clear that higher sensitivity (i.e., a lower degree of inflation anchoring) is negatively associated with average growth only for industries with above-median levels of external financial dependence.[1]

The rest of the empirical analysis aims at establishing the robustness of this main finding. We try to identify better industries that are likely to be credit constrained by also sorting industries in the sample by i) asset tangibility and ii) R&D intensity, in addition to external financial dependence shown above. These intrinsic characteristics are widely used as a proxy for credit constraints at the industry-level (Braun and Larrain, 2005; Ilyina and Samaniego, 2011; Aghion et al., 2014).

In addition, we also disentangle the effect of inflation anchoring from the effect of the level of inflation by explicitly controlling for the interaction between the level of inflation and industry-specific measures of credit constraints. While these two channels tend to be correlated, since low inflation is often achieved by better inflation anchoring (or a low-inflation

[1] The slope coefficients of the left (right) panel are 0.82 and -27.69 and the associated t-statistics using robust standard errors are 0.06 and -2.14, respectively.

environment fosters well-anchored inflation expectations), the results of the analysis suggest that is inflation anchoring and not the level of inflation *per se* that has a statistical effect on growth (at least through the credit constraints channel).

Finally, the results are robust to controlling for the interaction between sectoral credit constraints measures and a broad set of macroeconomic variables over the sample period—such as financial development, inflation, the size of government, overall economic growth, monetary policy counter-cyclicality and the level of inflation—and to IV techniques, using monetary policy transparency and independence as instruments.

The paper contributes to two streams of the literature. The first is on the effect of inflation on growth (see Judson and Orphanides 1999, and references therein for a review). The second is on the role of financial frictions in amplifying the effect of uncertainty about the economic environment—due either to shocks or stabilization policies—on growth.[2]

The remainder of the paper is organized as follows. Section II outlines the credit constraint channel through which inflation anchoring can affect growth and its empirical proxies. Section III describes the underlying data used in the analysis and how we construct our measure of inflation anchoring. Section IV explains our difference-in-difference methodology. Section V presents the main results and a battery of robustness exercises. Conclusions are in Section VI.

II. Inflation Anchoring and Growth: The Role of Credit Constraints

What are the channels through which inflation anchoring affects industry growth? In principle, inflation anchoring reduces uncertainty regarding the future level of inflation so that firms and households can make more informed decisions regarding their investment and

[2] See Aghion et al., 2014, Aghion et al., 2015, Christiano et al., 2014, Gilchrist et al., 2014, Alfaro et al., 2016, Choi et al., 2017, Choi, forthcoming.

consumption (or saving), as described in theoretical work by Bernanke (1983) and Pindyck (1988).

Aghion et al. (2010) develop this framework by showing that credit frictions are a key channel through which uncertainty affects medium-term growth. In their theory, firms can invest either in short-term projects or in productivity-enhancing longer-term projects that are subject to liquidity risk. If credit constraints bind only during periods of contractions, reducing the volatility of aggregate shocks increases the likelihood that long-term projects survive liquidity shocks in bad states without affecting what happens in good states (when credit constraints are not binding). Thus, the higher the fraction of credit constrained firms, the larger the positive effect of reducing uncertainty (or volatility). This mechanism suggests that uncertainty about economic policies would have larger effects on productivity-enhancing investment in more credit-constrained industries.

Following Aghion et al. (2014) as a benchmark for our analysis, we conduct a similar industry-level analysis on the channel through which inflation anchoring affects industry growth. We discuss several intrinsic characteristics at the industry level that are known to capture the degree of credit constraints. Our discussion draws largely from previous studies on technology and growth at the industry level (Braun and Larrain, 2005; Ilyina and Samaniego, 2011; Aghion et al., 2014; Samaniego and Sun, 2016).

External financial dependence

The interaction between firms' external financial dependence and macroeconomic environment, including policies has been widely studied in the existing literature (for example, Rajan and Zingales, 1998, Braun and Larrain, 2005, and Ilyina and Samaniego, 2011). Recently, Aghion et al. (2014) use external financial dependence as a proxy for industry-level credit constraints and find that industries with a relatively heavier reliance on external finance tend to grow faster in countries with more countercyclical fiscal policies. To test whether inflation anchoring has a similar stabilizing effect through the credit constraint channel, it is crucial to examine the external financial dependence channel. Following Rajan and Zingales (1998), dependence on external finance in each industry is measured as the median across all

U.S. firms, in each industry, of the ratio of total capital expenditures minus the current cash flow to total capital expenditures. We use an updated version of this indicator from Tong and Wei (2011).[3] Based on the previous empirical evidence, we expect a positive sign on the interaction term between the degree of external finance and the measure of inflation anchoring.

Asset tangibility

If inflation anchoring affects industry growth through the credit constraint channel, we should expect that inflation anchoring increases growth in industries with lower asset tangibility. It is because intangible assets are harder to use as collateral (Hart and Moore, 1994) so that an industry with less tangible capital tends to be more credit constrained. We take industry-level asset tangibility indicators from Samaniego and Sun (2016), who updated the values in Braun and Larrain (2005) and Ilyina and Samaniego (2011) using the ratio of fixed assets to total assets from US Compustat data.

R&D intensity

R&D-intensive industries can be more credit constrained for several reasons. First, while R&D typically requires large startup investments, its return often realizes with a significant lag. In the meantime, firms may find it difficult to finance their operational costs and are forced to rely on external financing. Second, R&D is an intangible asset that is difficult to collateralize, which also makes R&D intensive firms difficult to raise external finance. This channel is also consistent with most of the empirical evidence suggesting a negative relationship between uncertainty and R&D investment (Goel and Ram, 2001; Czarnitzki and Toole, 2011; Furceri and Jalles, forthcoming). We adopt the industry-level indicators from Samaniego and Sun (2016) who measure R&D intensity as R&D expenditures over total capital expenditure using the Compustat data.

[3] The updated data have been kindly provided by Hui Tong.

III. Data

A. Inflation Anchoring

We begin by assessing the sensitivity of medium-term inflation expectations in response to inflation surprises. Following Levin et al. (2004), we relate changes in inflation expectations to changes in inflation. In particular, the following equation is estimated for each country *i* in the sample:

$$\Delta\pi^{e}_{i,t+h} = \beta^{h}_{i}\pi^{news}_{i,t} + \varepsilon_{i,t+h}, \tag{1}$$

where $\Delta\pi^{e}_{i,t+h}$ denotes the first difference in expectations of inflation h years in the future—we use medium-term (that is, five-year ahead) inflation expectations in the baseline, and we check the sensitivity of the results to inflation expectations at shorter horizons[4], and $\pi^{news}_{i,t}$ is a measure of inflation shocks—defined as the difference between actual inflation and short-term inflation expectations from Consensus Economics. We use survey-based measures of professional forecasters' inflation expectations from Consensus Economics that are available at different horizons for a large set of countries.[5] The coefficient β^{h}_{i} captures the degree of anchoring in h-years-ahead inflation expectations—a term usually referred to as "shock anchoring" (Ball and Mazumder, 2011) with smaller values of the coefficient denoting well-anchored inflation expectations.

The quarterly forecast error is used as a baseline measure of inflation shocks for the analysis because it is less subject to reverse causality than other measures, such as changes in inflation or deviations of inflation from target. Nevertheless, we still test the robustness of our

[4] The baseline specification is estimated using five-year-ahead inflation expectations from Consensus Economics, for two reasons: i) inflation expectations at this horizon are a close proxy for central banks' inflation targets, so that the parameter β can be interpreted as the degree to which the headline inflation is linked to the central bank's target—a phenomenon typically referred to as "level anchoring" (Ball and Mazumder 2011) and ii) medium-term inflation expectations are less correlated with current and lagged inflation and hence are less subject to problems of multicollinearity and reverse causality.

[5] See IMF (2016) for further details on how Consensus forecasts are constructed.

findings by using alternative measures of inflation shocks. The sensitivity of inflation expectations for the survey-based forecast is normalized to measure how much inflation expectations are updated in response to a one percentage point change in inflation.

If monetary policy is credible, the value of this parameter at a sufficiently long horizon should be close to zero. That is, inflation shocks should not lead to changes in medium-term expectations if agents believe that the central bank can counteract any short-term developments to bring inflation back to the target over the medium term. Given the uncertainty about the relevant horizon for firms' pricing decisions and in light of the previous results, we use inflation expectations at various horizons. The model is estimated for each advanced and emerging market economy for which survey-based inflation expectation data are available, which produces estimates for 44 countries where Consensus forecasts are available from 1990 to 2014.

In Figure 2, we first present the evolution of the left-hand-side (top panel) and right-hand-side (bottom panel) variables in equation (1) for advanced and emerging market economies. Changes in inflation expectations have been more volatile at shorter horizons for both groups of countries. Expectations were on a downward path throughout the 1990s in both advanced and emerging market economies as monetary frameworks were improving and inflation was falling. This trend was particularly strong in emerging market economies. Inflation expectations have been remarkably stable throughout the 2000s in advanced economies, especially at longer horizons, but recently their volatility has increased. In contrast, for emerging market economies the volatility of expectations during 2009–14 has been lower than in the previous decade. Inflation shocks have been relatively modest in advanced economies, except for the period surrounding the global financial crisis. These shocks were mostly negative in the 1990s as inflation was declining, but have been close to zero in the 2000s. Since 2011, the median inflation shock in advanced economies was negative. In emerging market economies, inflation shocks were negative on average in the 1990s and early 2000s, but less so more recently.

The coefficient of the sensitivity of inflation expectations (or inverse of inflation anchoring) used in equation (1) is estimated for the final sample of 36 countries. While the average of the sensitivity coefficients is 0.03, their standard deviation is 0.05, implying large variations across countries. In particular, there is considerable heterogeneity in the size of the sensitivity among countries, with advanced economies having higher inflation anchoring than emerging market economies. We will exploit this cross-country variation to identify the causal effect of inflation anchoring on industry growth.

B. UNIDO data

Industry-level dependent variables are taken from the United Nations Industrial Development Organization (UNIDO) database. While Aghion et al. (2014) use the KLEMS database in their analysis of advanced economies, UNIDO database allows us to study not only advanced but also emerging market economies.[6] The extension of the analysis towards emerging market economies is particularly meaningful for the econometric setup in our analysis. Although our difference-in-difference methodology mitigates endogeneity issues by controlling for unobserved heterogeneity and reducing the chance of reverse causality as discussed in Aghion et al. (2014), successful identification hinges critically on variations in the measure of inflation anchoring across countries. To the extent that the conduct of monetary policy in many emerging market economies still suffers from the lack of transparency or independence of their central banks, a study of these economies provides an opportunity to study the causal link from inflation anchoring to industry growth.

We measure industry growth by value-added growth.[7] All nominal variables are deflated by the country-level Consumer Price Index of the local currency taken from the World

[6] In addition to the increase in country coverage, UNIDO provides information on more disaggregated manufacturing industries compared to KLEMS.

[7] Similar results are obtained using gross output instead. See the sub-section on robustness checks.

Economic Outlook database. All of these variables are reported for 22 manufacturing industries based on the INDSTAT2 2016, ISIC Revision 3.[8]

C. Industry-level characteristics

In this section, we report the measures of industry characteristics described earlier for 22 manufacturing industries that are constructed from the U.S. firm-level data. INDSTAT2 industry classification is similar to that of INDSTAT3 used in the earlier literature (Braun and Larrain, 2005; Ilyina and Samaniego, 2011), with a minor exception.[9] For example, whereas "manufacture of food products and beverages" (ISIC 16) is the first industry in the INDSTAT2 dataset, the INDSTAT3 dataset disaggregates them into "manufacture of food products" (ISIC 311) and "manufacture of beverages" (ISIC 313). Following Choi et al. (forthcoming), we take the average of the industry characteristics for ISIC 311 and ISIC 313 to obtain the value for ISIC 16 in this case. If two datasets share the same industry, we simply use the values of INDSTAT3. Table A.1 in the Appendix compares the industry classification between INDSTAT2 and INDSTAT3.

We draw on Rajan and Zingales (1998), Braun and Larrain (2005), Ilyina and Samaniego (2011), and Samaniego and Sun (2016) to compute industry-level indicators. Table 1 reports the measures of industry characteristics. Table 2 shows the correlation matrix amongst these variables. The correlations amongst industry characteristics measures are intuitive and consistent with what existing theories would predict. For example, as described in Choi et al. (forthcoming), an industry that relies more heavily on external finance also tends to have lower asset tangibility and higher R&D intensity. However, this correlation is far from perfect. For example, the correlation between external financial dependence and asset tangibility is only -0.27.

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[8] While the original INDSTAT 2 database includes 23 manufacturing industries, exclude the "manufacture of recycling" industry due to the insufficient observations.

[9] There are 28 manufacturing industries in INDSTAT3.

Our final sample consists of an unbalanced panel of 36 countries. Table 3 summarizes the final country coverage and the number of observations used in the analysis. We do not include the U.S. in the final sample, as the industrial characteristics are measured from U.S. firm-level data. To the extent that inflation anchoring in the U.S. influence the U.S. firms from different industries in a systematic way, the inclusion of the U.S. would bias the result.[10]

IV. METHODOLOGY

To assess the effect of inflation anchoring on growth and identify the relevant transmission channels, the analysis follows the methodology proposed by Rajan and Zingales (1998). The following specification is estimated for an unbalanced panel of 36 countries and 22 manufacturing industries:

$$g_{i,c} = \alpha_i + \alpha_c + \delta X_i Z_c + \mu log y_{i,c}^0 + \varepsilon_{i,c}, \qquad (2)$$

where *i* denotes industries and *c* denotes countries. *g* is a measure of industry growth, which is the average growth from 1990 to 2014; y^0 is the initial share of each manufacturing sector *i* in a country *c* of the total manufacturing output in 1990 measured by value added; *X* is a measure of an industry characteristic for an industry *i*, such as external financial dependence; *Z* is our measure of inflation anchoring for each country *c*;[11] α_i and α_c are industry and country fixed effects, respectively.

Equation (2) is estimated using OLS—and standard errors are clustered at the country level—as the inclusion of fixed effects is likely to address the endogeneity concerns related to omitted variable bias. Also, reverse causality issues are unlikely. First, related to the measures of industry characteristics, it is hard to conceive that sectoral growth in other countries can influence the U.S. industry's characteristics. Second, it is very unlikely that growth at the industry-level can influence the aggregate measures of inflation anchoring. Claiming reverse

[10] In a later draft, we will report the results when the U.S. is included as well.

[11] A higher sensitivity coefficient means a lower degree of inflation anchoring.

causality is equivalent to arguing that differences in growth across sectors lead to differences in the degree of inflation anchoring—which we believe to be unlikely.

However, a remaining possible concern in estimating equation (2) with OLS is that other macroeconomic variables could affect industry growth when interacted with industries' certain characteristics and they are also correlated with our inflation anchoring measure. For example, this concern could be the case for financial development—the original channel assessed by Rajan and Zingales (1998)—but also for the level of inflation itself. We address this issue in the subsection devoted to robustness checks.

V. Results

A. Baseline results

Table 4 presents the results obtained by estimating equation (2). They report the interaction effects of inflation anchoring and various industrial characteristics capturing the credit constraint channel on growth, together with the coefficient capturing the catch-up effect. First, the catch-up effect exists strongly, as the coefficient on the initial share of each manufacturing sector is negative and statistically significant at the 1 percent level. Second, the signs of the interaction terms are consistent with the credit constraint channel. We find that inflation anchoring (or equivalently, the lower sensitivity of inflation expectations in response to inflation surprises) increases growth more for industries with: i) higher external financial dependence, ii) lower asset tangibility, iii) higher R&D intensity. The effects through these three channels are statistically significant at the 5 percent level.

To gauge the magnitude of each channel, we measure differential growth gains from a decrease in the sensitivity coefficient from the 75th to the 25th percentile of the distribution for an industry at the 75th percentile of the distribution compared to the industry at the 25th percentile. The magnitude of the interaction effects of inflation anchoring ranges from 0.6 for asset tangibility to 1.2 percentage points for external financial dependence. For example, the results suggest that the differential growth gains are 1.2 percentage points by improving inflation anchoring from the level of Czech Republic to that of Italy and simultaneously moving from an industry with low external financial dependence to an industry with high external financial dependence. While these magnitudes seem large at first glance, moving from the 25th to the 75th percentile in the sensitivity of inflation expectations implies a quite dramatic change in the credibility of monetary policy, which is unlikely to happen in any individual country over a short period.

B. Robustness checks

Alternative growth measure

While value-added measures an industry's ability to generate income and contribute to GDP, gross output principally measures overall production at market prices. The difference between gross output and value added of an industry is intermediate inputs. To the extent that the intensity of intermediate inputs varies across countries within the same industry, our growth measure based on value-added might not necessarily give us the same picture as a gross output measure. To check this possibility, we repeat our analysis using the average growth rate of gross output. Gross output is also deflated using the CPI to obtain real values. Table 5 confirms that the sign, size, and statistical significance of the interaction effects using gross output are largely similar to those using value added, lending support to our baseline results. The only difference is that the asset tangibility channel is no longer statistically significant using gross output.

Uncertainty in the estimates of the degree of inflation anchoring

A possible limitation of the analysis is that our measure of the degree of inflation anchoring is estimated and not directly observable. It implies that the above findings could just reflect that the standard errors around the inflation anchoring estimates are not properly considered. To address this limitation, we re-estimate equation (2) using Weighted Least Squares (WLS), with weights given by the inverse of the standard deviation of the estimated sensitivity coefficients. The results of this exercise are reported in Table 6. The estimated parameters are similar to those obtained using OLS, suggesting that baseline results appear not to be biased using a generated regressor.

Alternative measure of the degree of inflation anchoring

We have used an inflation anchoring measure based on the deviation of inflation expectations at the medium-term horizon in response to inflation shocks—defined as the difference between actual inflation and short-term inflation expectations. The baseline specification is estimated using five-year-ahead inflation expectations from Consensus Economics, for two reasons: i) inflation expectations at this horizon are a close proxy for central banks' inflation targets, so that the parameter β can be interpreted as the degree to which the headline inflation is linked to the central bank's target—a phenomenon typically referred to as "level anchoring" (Ball and Mazumder 2011) and ii) medium-term inflation expectations are less correlated with current and lagged inflation and hence are less subject to problems of multicollinearity and reverse causality.

To test the robustness of our findings, we use alternative measures of the degree of inflation anchoring by using i) inflation expectations at the short-term horizon (1-year-ahead); ii) alternative inflation shocks—defined as the change in short-term inflation expectations themselves; and iii) the absolute sensitivity of the medium-term inflation expectations. The correlation between the baseline measure of the degree of inflation anchoring with these alternative measures is 0.58, 0.48, and 0.85, respectively. The results obtained by estimating equation (2) with these alternative measures of inflation anchoring are reported in Table 7. Column (I) to (IV) present the results using short-term inflation expectations, column (V) to (VII) present the results using alternative inflation shocks, and column (VIII) to (IX) present the results using the absolute sensitivity of the medium-term inflation expectations. They confirm a statistically significant effect of inflation anchoring on industry growth through external financial dependence, asset tangibility and R&D intensity channels, consistent with the results from the baseline specification and other sensitivity tests.[12]

[12] The results are robust when replacing 1-year-ahead inflation expectations with 2, 3, and 10 year-ahead inflation expectations. To save space, the results are available upon request.

Different factors and omitted variable bias

As discussed before, a possible concern in estimating equation (2) is that results could be biased due to the omission of macroeconomic variables affecting industry growth through the specific channel that is, at the same time, correlated with our measure of inflation anchoring. Thus, we augment equation (2) by interacting each additional country-specific variable W_c with industry characteristics to check whether the inclusion of other variables alters the effect of inflation anchoring on industry growth. The parameter θ in equation (3) aims to capture this additional interaction effect.

$$g_{i,c} = \alpha_i + \alpha_c + \beta X_i Z_c + \theta X_i W_c + \mu log y_{i,c}^0 + \varepsilon_{i,c}. \qquad (3)$$

The first obvious candidate to consider is the level of financial development. To the extent that the lack of financial depth weakens the transmission channel of monetary policy, our measure of inflation anchoring simply captures financial development. Acemoglu and Zilibotti (1997) also claim that low financial development as a factor that could both reduce long-run growth and increase the volatility of the economy. We use the average of the ratio of bank credit to the private sector to GDP (the main variable used in Rajan and Zingales, 1998) between 1990 and 2014.

A second potential variable is the level of inflation, which may lead to capital misallocation because high inflation makes it difficult for investors to sort out productive investment opportunities (Fischer and Modigliani, 1978; Modino et al., 1996) and to the extent that some industries are more vulnerable to capital misallocation, it may have larger negative effects on these industries. These two channels, however, are correlated in practice since low inflation is often achieved by better inflation anchoring (or a low-inflation environment fosters well-anchored inflation expectations). Thus, we control for the average of the annual CPI inflation between 1990 and 2014.

Third, we control for the size of government, which is known to be positively correlated with the countercyclicality of fiscal policy (Aghion et al., 2014; Choi et al., 2017) and also governing the relationship between output volatility and growth (Fátas and Mihov, 2001; Debrun et al., 2008; Afonso and Furceri, 2010). We measure the government size by the average of the ratio of government expenditure to GDP between 1990 and 2014.

The fourth candidate to consider is the economy-wide growth. If countries with a better monetary policy framework achieve faster economic growth overall, the interaction effect we found earlier might simply capture different elasticities of industry growth to aggregate growth. To control for the effect of overall growth, we interact the average of the annual real GDP growth between 1990 and 2014 with the industrial characteristics capturing credit constraints.

Lastly, the countercyclicality of real short-term interest rates may also capture the stabilizing effect of monetary policy similar to inflation anchoring. Using industry-level value-added growth from the 15 OECD countries over the period 1995-2005, Aghion et al. (2015) find that industries relying heavily on external finance tend to grow faster in a country with a more countercyclical real short-term interest rate. Similar to the argument from Aghion et al. (2014), financially constrained industries benefit more from the stabilizing effect of the countercyclical monetary policy. Following Aghion et al. (2015), we measure the countercyclicality by the sensitivity of real short-term interest rate to real GDP growth, controlling for the one-quarter-lagged real short-term interest rate.[13] Among the 36 countries in our sample, we obtain the countercyclicality of real short-term interest rates from 28 countries.

Figure 3 provides correlations between the degree of inflation anchoring and macroeconomic variables that may affect industry growth. Indeed, the level of financial development, the level of inflation, the size of government expenditure, overall growth, and the countercyclicality of real short-term interest rates are correlated with the degree of inflation anchoring with the expected signs. A country with well-anchored inflation expectations tends to have a deeper financial market, a lower average level of inflation, a larger government, a

[13] We measure the short-term interest rate by the money market rate. Real interest rates are calculated by subtracting the annualized CPI inflation from nominal interest rates. To be comparable to our measure of inflation anchoring, we run the estimation over the period 1990-2014. For the euro-zone countries with a common monetary policy since the introduction of the euro, the estimation is only conducted for the pre-euro period.

higher overall growth, and a more countercyclical real short-term interest rate. The correlations between these five variables and the sensitivity of inflation expectations are -0.26, 0.56, -0.24, -0.13, and -0.18, respectively.

Table 8 shows that the significant interaction effect of inflation anchoring and the three measures of the credit constraint channel remain significant in all the cases. Interestingly, the interaction coefficient of the average level of inflation with the credit constraint channel is not statistically significant, suggesting that what matters for firms' decisions is whether they operate in a predictable inflation environment rather than the level of inflation itself. While the countercyclicality of real short-term interest rates is only significant when interacting with R&D intensity (Table 9), it does not necessarily contradict with Aghion et al. (2015), as our sample is substantially larger than Aghion et al. (2015) in which 13 out of 15 countries are European countries.

Instrumental variables

We further address endogeneity concerns using an IV approach. Specifically, we use the following set of indicators regarding the institutional quality of central banks as instruments: (i) the central bank governor turnover index; (ii) the central bank independence index; and (iii) the central bank transparency index. These indicators are largely exogenous to our dependent variable of industry-level value-added growth, but they are strongly correlated with the degree of inflation anchoring since inflation expectations tend to be better anchored in a country with an independent and transparent central bank. We take the indicators from the dataset constructed by Crowe and Meade (2007). Seeking for further exogeneity of our instrumental variables, we use the values of the central bank governor turnover index and the central bank independence index constructed from the institutional data between 1980 and 1989 only, which does not overlap with our main sample period of 1990-2014. Among the 36 countries in our sample, the three indicators are available for 25 countries.

We proceed in two steps. In the first step, we regress the degree of inflation anchoring on the three instrumental variables, controlling for the industry- and country-fixed effects. The results of the first stage in Table 10 confirm that these three instruments can be considered as "strong instruments"—that is, the Cragg-Donald Wald F-statistics are well above the Stock and Yogo (2005) critical values for weak instruments in all cases. Hansen's J statistics for valid instruments is also reported in Table 10. In the second step, we re-estimate equation (2) using the exogenous part of the degree of inflation anchoring driven by these three instruments—that is, the fitted value of the first step. The results reported in Table 9 confirm that inflation anchoring enhances growth more for industries with higher external financial dependence and R&D intensity albeit with smaller effects than the OLS case—even though the difference is not statistically significant.

VI. Conclusions

By applying a difference-in-difference approach to a large industry-level panel data including both advanced and emerging market economies, this paper has examined how the effect of inflation anchoring on growth depends on intrinsic characteristics capturing credit constraints. We find that inflation anchoring fosters industry growth through the credit constraint channel, as measured high external financial dependence and R&D intensity and low asset tangibility.

The results are robust to controlling for the interaction between technological characteristics and a broad set of macroeconomic variables, such as financial development, inflation, size of government, and overall economic growth. Since our finding can answer which kind of industries are expected to benefit more by anchoring inflation expectations, it also sheds light on economy-wide gains from improving the monetary policy framework. For example, improving a monetary policy framework to anchor inflation expectations is expected to be more growth-friendly in an economy with a larger share of credit constrained industries, or in periods where credit constraints are more binding (such as during periods of recession).

Finally, the results of the analysis suggest that it is inflation anchoring and not the level of inflation *per se* that has a statistical effect on growth, at least through the credit constraints channel.

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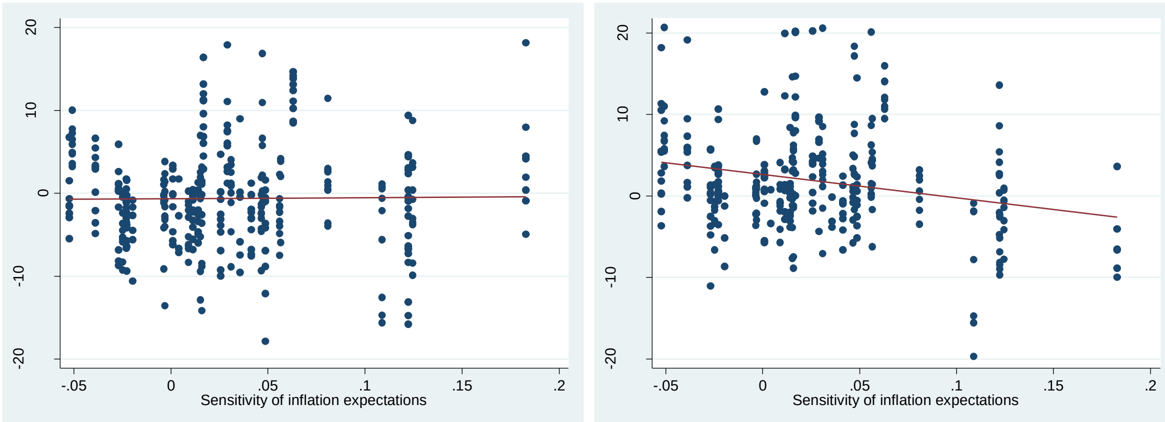
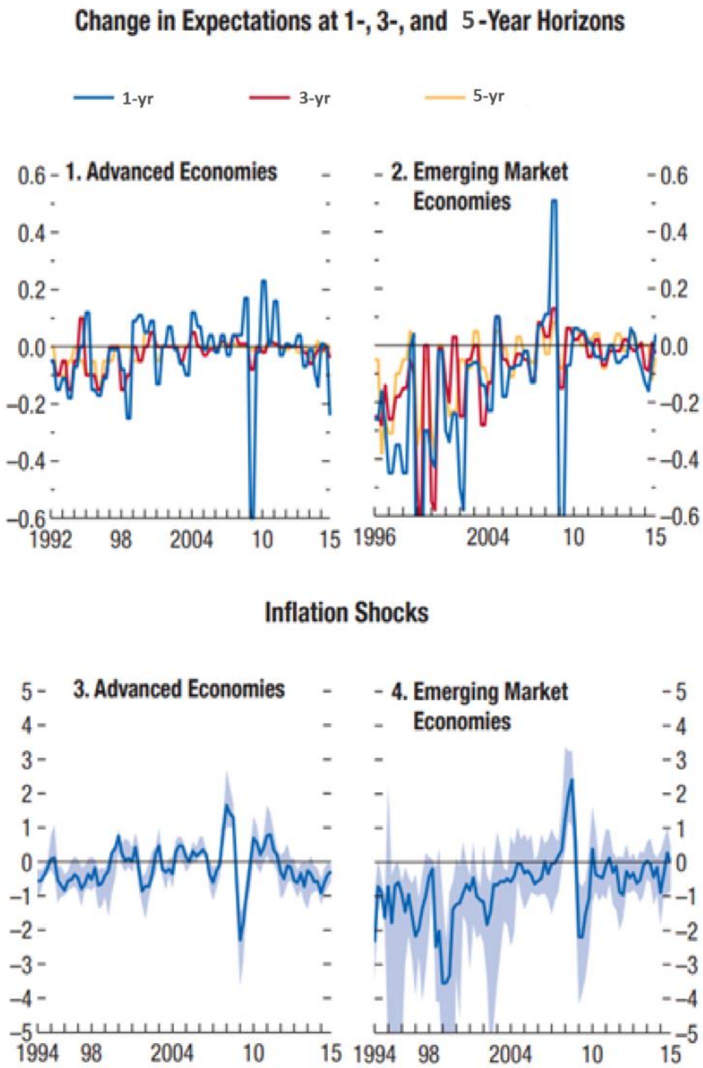
Figure 1. Inflation anchoring and industry growth: the role of credit constraints



Note: The left (right) panel is the scatter plot of the average real value added growth for industries with below (above) median external financial dependence against the sensitivity of the medium-term (five-year) inflation expectations in response to inflation surprises, controlling for the initial share of each industry and industry-fixed effects. The slope coefficients of the left (right) panel are 0.82 and -27.69 and the associated t-statistics using robust standard errors are 0.06 and -2.14, respectively.

Figure 2. Change in inflation expectations and inflation shocks (percentage points)



Note: Data used in this figure are quarterly. In panels 3 and 4, blue lines denote the median of inflation shocks, and shaded areas denote interquartile ranges.

Figure 3. Correlations between the sensitivity of inflation expectations and other factors

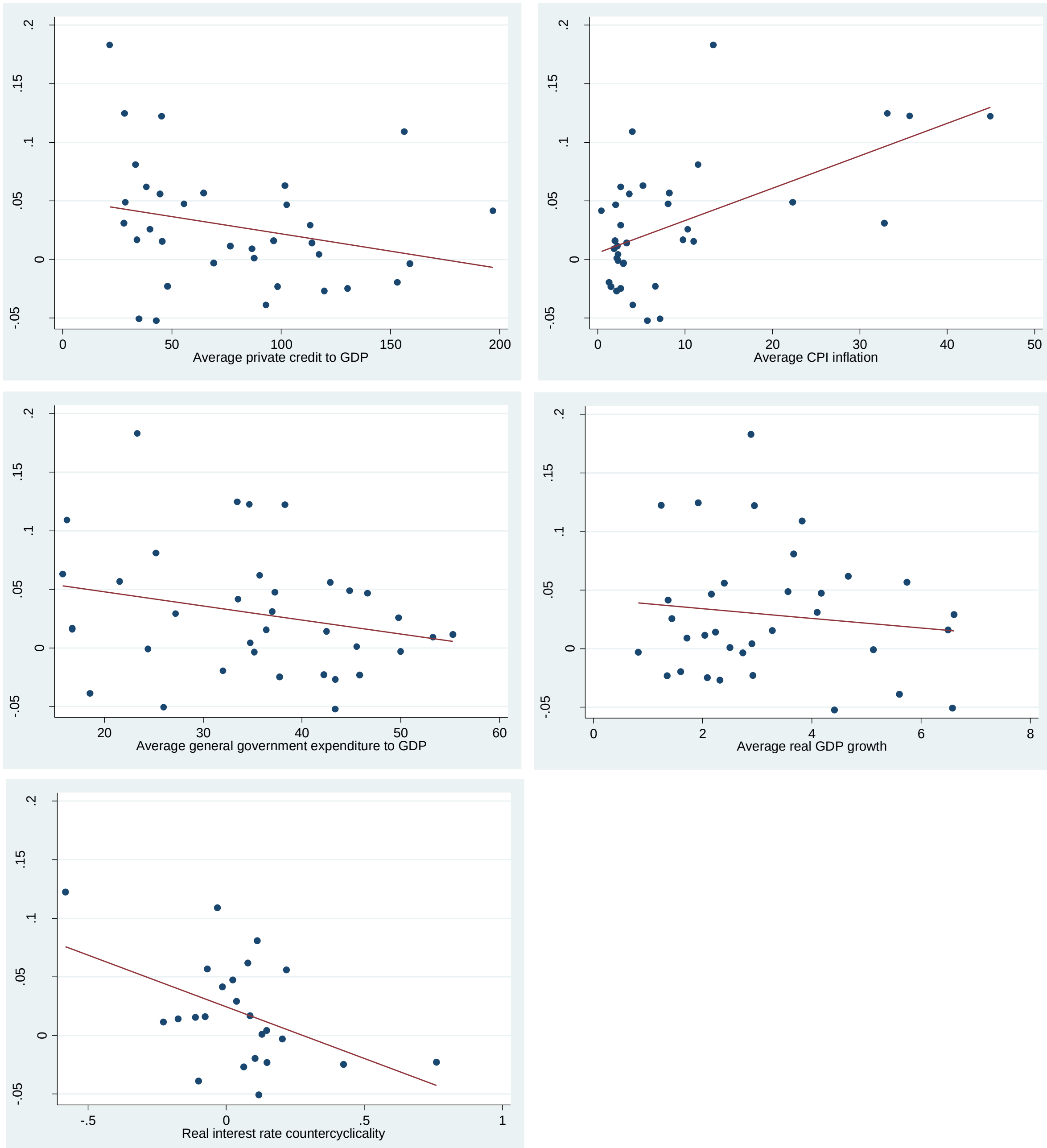


Table 1. Industry-specific intrinsic characteristics

ISIC code	Industry	External financial dependence	Asset tangibility	R&D intensity
15	Food products and beverages	0.11	0.37	0.06
16	Tobacco products	-0.45	0.19	0.22
17	Textiles	0.19	0.35	0.14
18	Wearing apparel; dressing and dyeing of fur	0.03	0.13	0.02
19	Tanning and dressing of leather	-0.14	0.15	0.18
20	Wood and of products of wood and cork, except furniture	0.28	0.31	0.03
21	Paper and paper products	0.17	0.47	0.08
22	Publishing, printing and reproduction of recorded media	0.20	0.26	0.10
23	Coke, refined petroleum products and nuclear fuel	0.04	0.48	0.12
24	Chemicals and chemical products	0.50	0.29	1.11
25	Rubber and plastics products	0.69	0.35	0.18
26	Other non-metallic mineral products	0.06	0.48	0.10
27	Basic metals	0.05	0.40	0.08
28	Fabricated metal products, except machinery and equipment	0.24	0.27	0.15
29	Machinery and equipment n.e.c.	0.60	0.20	0.93
30	Office, accounting and computing machinery	0.96	0.18	1.19
31	Electrical machinery and apparatus n.e.c.	0.95	0.21	0.81
32	Radio, television and communication equipment and apparatus	0.96	0.18	1.19
33	Medical, precision and optical instruments, watches and clocks	0.96	0.18	1.19
34	Motor vehicles, trailers and semi-trailers	0.36	0.26	0.32
35	Other transport equipment	0.36	0.26	0.32
36	Furniture; manufacturing n.e.c.	0.37	0.28	0.16

Table 2. Correlation matrix of industry-specific characteristics

	External financial dependence	Asset tangibility	R&D intensity
External financial dependence	1		
Asset tangibility	-0.27	1	
R&D intensity	0.73	-0.40	1

Table 3. Country coverage and the number of industries used in the analysis

Country	Number of industries	Country	Number of industries
Australia	11	Lithuania	18
Brazil	21	Malaysia	18
Canada	22	Mexico	16
Chile	12	Netherlands	20
China	18	New Zealand	5
Colombia	18	Norway	21
Czech Republic	18	Poland	22
Estonia	19	Romania	18
France	21	Russia	18
Germany	20	Singapore	22
Hong Kong	17	Slovakia	20
Hungary	21	Slovenia	16
India	21	Spain	22
Indonesia	20	Sweden	22
Italy	22	Switzerland	11
Japan	20	Taiwan	16
Korea	22	Turkey	22
Latvia	18	United Kingdom	20

Table 4. The effect of inflation anchoring on industry growth: Value added

Explanatory variable	(I)	(II)	(III)
Log of initial share	-0.959***	-0.904***	-0.952***
	(0.287)	(0.300)	(0.291)
External financial dependence *Inflation anchoring	-39.860***		
	(11.911)		
Asset tangibility *Inflation anchoring		66.067**	
		(27.415)	
R&D intensity *Inflation anchoring			-26.960***
			(8.512)
Magnitude of differential effects	-1.24	0.61	-1.12
Observations	668	668	668
R-squared	0.6	0.59	0.59

Note: The dependent variable is the average annual growth rate in real value added from 1990 to 2014 for each industry-country pair. Initial share in manufacturing value added is the ratio of industry-level real value added to total real manufacturing value added in the initial period. T-statistics based on clustered standard errors at the country level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Table 5. The effect of inflation anchoring on industry growth: Gross output

Explanatory variable	(I)	(II)	(III)
Log of initial share	-0.798***	-0.761***	-0.791***
	(0.259)	(0.266)	(0.266)
External financial dependence *Inflation anchoring	-35.787**		
	(15.321)		
Asset tangibility *Inflation anchoring		36.717	
		(33.957)	
R&D intensity *Inflation anchoring			-23.030***
			(7.550)
Magnitude of differential effects	-1.18	0.34	0.96
Observations	668	668	668
R-squared	0.61	0.60	0.60

Note: The dependent variable is the average annual growth rate in gross output from 1990 to 2014 for each industry-country pair. Initial share in manufacturing value added is the ratio of industry-level real value added to total real manufacturing value added in the initial period. T-statistics based on clustered standard errors at the country level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Table 6. The effect of inflation anchoring on industry growth: WLS

Explanatory variable	(I)	(II)	(III)
Log of initial share	-0.927**	-0.794*	-0.913**
	(0.362)	(0.409)	(0.375)
External financial dependence *Inflation anchoring	-48.005***		
	(11.072)		
Asset tangibility *Inflation anchoring		84.018***	
		(19.455)	
R&D intensity *Inflation anchoring			-33.032***
			(10.206)
Magnitude of differential effects	-1.50	0.78	-1.37
Observations	668	668	668
R-squared	0.60	0.60	0.60

Note: The dependent variable is the average annual growth rate in real value added from 1990 to 2014 for each industry-country pair. Initial share in manufacturing value added is the ratio of industry-level real value added to total real manufacturing value added in the initial period. T-statistics based on clustered standard errors at the country level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Table 7. The effect of inflation anchoring on industry growth: Alternative measure of the degree of inflation anchoring

	Short-term expectations (one year)			Alternative inflation shocks			Absolute sensitivity		
Explanatory variable	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
Log of initial share	-0.959**	-0.924*	-0.953**	-0.983***	-0.936***	-0.956***	-0.960***	-0.887***	-0.932***
	(0.308)	(0.310)	(0.308)	(0.301)	(0.303)	(0.305)	(0.282)	(0.298)	(0.294)
External financial dependence *Inflation anchoring	-3.533***			-15.540***			-60.016***		
	(1.189)			(5.406)			(13.118)		
Asset tangibility *Inflation anchoring		7.435***			13.176			108.864***	
		(2.389)			(15.912)			(29.334)	
R&D intensity *Inflation anchoring			-2.417**			-13.005***			-38.665***
			(1.128)			(4.131)			(11.166)
Magnitude of differential effects	-0.33	0.21	-0.30	-0.85	0.21	-0.94	-1.28	0.68	-1.09
Observations	668	668	668	668	668	668	668	668	668
R-squared	0.59	0.59	0.59	0.60	0.60	0.60	0.59	0.59	0.59

Note: The dependent variable is the average annual growth rate in real value added from 1990 to 2014 for each industry-country pair. Initial share in manufacturing value added is the ratio of industry-level real value added to total real manufacturing value added in the initial period. T-statistics based on clustered standard errors at the country level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Table 8. The effect of inflation anchoring on industry growth: Omitted variable bias and alternative explanation

	Financial development			Inflation			Government size		
Explanatory variable	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
Log of initial share	-0.833***	-0.899***	-0.963***	-0.946***	-0.877***	-0.966***	-1.021***	-0.869***	-0.960***
	(0.287)	(0.293)	(0.307)	(0.279)	(0.288)	(0.296)	(0.268)	(0.295)	(0.287)
External financial dependence *Inflation anchoring	-43.443***			-44.067**			-36.761***		
	(15.663)			(21.32)			(10.911)		
Asset tangibility *Inflation anchoring		72.731**			98.231**			58.172**	
		(29.922)			(41.813)			(24.849)	
R&D intensity *Inflation anchoring			-21.186**			-16.958*			-25.677***
			(7.985)			(9.217)			(8.969)
Magnitude of differential effects	-1.36	0.67	-0.88	-1.38	0.90	-0.71	-1.15	0.54	-1.07
External financial dependence *Other variables	-0.037**			0.025			0.131**		
	(0.017)			(0.069)			(0.054)		
Asset tangibility *Other variables		0.068*			-0.203			-0.227*	
		(0.034)			(0.160)			(0.133)	
R&D intensity *Other variables			-0.009			-0.063			0.035
			(0.009)			(0.037)			(0.039)
Observations	650	650	650	668	668	668	668	668	668
R-squared	0.59	0.59	0.58	0.60	0.59	0.59	0.59	0.59	0.59

Note: The dependent variable is the average annual growth rate in real value added from 1990 to 2014 for each industry-country pair. Initial share in manufacturing value added is the ratio of industry-level real value added to total real manufacturing value added in the initial period. The bottom panel presents the interaction between industrial characteristics and other macroeconomic variables described in the first row. T-statistics based on clustered standard errors at the country level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Table 9. The effect of inflation anchoring on industry growth: Omitted variable bias and alternative explanation (continued)

	Overall growth			Interest rate countercyclicality		
Explanatory variable	(X)	(XI)	(XII)	(XIII)	(XIV)	(XV)
Log of initial share	-0.994***	-0.903***	-0.953***	-0.977***	-0.944***	-0.935***
	(0.282)	(0.300)	(0.291)	(0.304)	(0.311)	(0.306)
External financial dependence *Inflation anchoring	-41.278***			-47.610***		
	(11.686)			(12.27)		
Asset tangibility *Inflation anchoring		66.880**			83.099*	
		(27.773)			(46.047)	
R&D intensity *Inflation anchoring			-27.224***			-32.706***
			(8.398)			(7.651)
Magnitude of differential effects	-1.29	0.61	-1.13	-1.49	0.76	-1.36
External financial dependence *Other variables	-0.340			0.875		
	(0.208)			(1.301)		
Asset tangibility *Other variables		0.286			3.633	
		(0.689)			(5.515)	
R&D intensity *Other variables			-0.072			1.158*
			(0.171)			(0.670)
Observations	668	668	668	415	415	415
R-squared	0.59	0.59	0.59	0.56	0.56	0.56

Note: The dependent variable is the average annual growth rate in real value added from 1990 to 2014 for each industry-country pair. Initial share in manufacturing value added is the ratio of industry-level real value added to total real manufacturing value added in the initial period. The bottom panel presents the interaction between industrial characteristics and other macroeconomic variables described in the first row. T-statistics based on clustered standard errors at the country level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Table 10. The effect of inflation anchoring on industry growth: IV regression

Explanatory variable	(I)	(II)	(III)
Log of initial share	-0.972***	-0.970***	-0.962***
	(0.277)	(0.295)	(0.275)
External financial dependence *Inflation anchoring	-31.289**		
	(13.321)		
Asset tangibility *Inflation anchoring		44.842	
		(83.625)	
R&D intensity *Inflation anchoring			-23.171*
			(13.697)
Magnitude of differential effects	-0.98	0.41	-0.96
Cragg-Donald Wald F-statistic	61.202	54.172	57.908
Stock-Yogo weak identification test 5% critical values	13.91	13.91	13.91
Hansen J-statistic p-value	0.118	0.914	0.187
Observations	428	428	428
R-squared	0.42	0.39	0.42

Note: The dependent variable is the average annual growth rate in real value added from 1990 to 2014 for each industry-country pair. Initial share in manufacturing value added is the ratio of industry-level real value added to total real manufacturing value added in the initial period. T-statistics based on clustered standard errors at the country level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Appendix

Table A.1. Industry classification: INDSTAT2 vs. INDSTAT3

INDSTAT2		INDSTAT3	
ISIC	Industry	ISIC	Industry
15	Food products and beverages	311	Food
16	Tobacco products	313	Beverages
17	Textiles	314	Tobacco
18	Wearing apparel; dressing and dyeing of fur	321	Textiles
19	Tanning and dressing of leather	322	Apparel
20	Wood and of products of wood and cork, except furniture	323	Leather
21	Paper and paper products	324	Footwear
22	Publishing, printing and reproduction of recorded media	331	Wood products
23	Coke, refined petroleum products and nuclear fuel	332	Furniture, except metal
24	Chemicals and chemical products	341	Paper and products
25	Rubber and plastics products	342	Printing and publishing
26	Other non-metallic mineral products	351	Industrial chemicals
27	Basic metals	352	Other chemicals
28	Fabricated metal products, except machinery and equipment	353	Petroleum refineries
29	Machinery and equipment n.e.c.	354	Misc. pet. And coal products
30	Office, accounting and computing machinery	355	Rubber products
31	Electrical machinery and apparatus n.e.c.	356	Plastic products
32	Radio, television and communication equipment and apparatus	361	Pottery, china, earthenware
33	Medical, precision and optical instruments, watches and clocks	362	Glass and products
34	Motor vehicles, trailers and semi-trailers	369	Other nonmetallic mineral products
35	Other transport equipment	371	Iron and steel
36	Furniture; manufacturing n.e.c.	372	Nonferrous metals
		381	Fabricated metal products
		382	Machinery, except electrical
		383	Machinery, electric
		384	Transport equipment
		385	Prof. and sci. equip.
		390	Other manufactured products