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The empirical relevance of the Mises-Hayek theory of the trade cycle

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Abstract Austrian Business Cycle Theory (ABCT), as espoused by Mises (1953, 1949) and Hayek (1935), predicts changes in the economy's structure of production following an unexpected change in monetary policy. In particular, following a credit expansion the theory predicts that: previously idle resources are drawn into the market, previously employed resources are used more intensively, and prices and quantities of goods in the intermediate stages of production decline relative to the prices and quantities of goods in other stages. To test the theory's implications we employ stage of process data which classify goods by their distance to final consumption. Using this data we run structural vector autoregressions and isolate each variable's response to a monetary shock. Consistent with the theory, we find that resource use expands on the intensive and extensive margin. On the other hand, we find little evidence of the relative price and quantity effects predicted by ABCT. Since the relative price effects are the distinguishing aspect of ABCT, we conclude that evidence in favor of the theory is, at best, mixed.

JEL Classifications E32 · E52 · E53

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1 Introduction

The distinctive feature of Austrian macroeconomics is its serious treatment of the economy's structure of production. In contrast to other schools of economic thought, macroeconomists in the Austrian tradition see the economic process as inherently sequential and focus on the responses of relative prices and quantities at various stages in the production structure to exogenous economic events. Despite the theoretical importance of changes in the structure of production, little empirical evidence, with exceptions discussed below, has been documented establishing the validity of its predictions. We take steps towards filling this void.

The exogenous economic event studied in this paper is an expansion of credit by the central bank. In other words, we investigate the claims made by Austrian Business Cycle Theory (ABCT).[1] Our contribution is threefold. First, we introduce two publicly available data sets that explicitly distinguish industries and commodities by their distance from consumable output. This partitioning of industries and commodities is very close to what Austrians have in mind with "early stages", those far away from final consumable output, and "late stage", those close to final consumable output. Second, we carefully define what an "exogenous monetary policy shock" actually is and use established empirical methods to identify these shocks in the data.[2] Finally, we use structural vector autoregressions (VARs) to trace out the dynamic responses of relative prices and quantities of different stages of production in response to a monetary policy shock.

ABCT predicts that a central bank expansion leads to a misalignment of the natural and the market rate of interest with the latter decreasing relative to the former. Entrepreneurs mistakenly believe that consumers have shifted demand in favor of future consumption relative to current consumption and, consequently, move factors of production into earlier stages of production. While more resources are allocated to stages early in the production process, consumers simultaneously raise their demand for current goods due to the decrease in the market rate of interest. Mises (1953) referred to these phenomena as malinvestment and overconsumption and ascribed this behavior to the boom phase of a business cycle. Since the new entrepreneurial time pattern of production is inconsistent with consumer preferences, this structure of production is unsustainable and eventually must be corrected. Entrepreneurs facing increasingly binding resource constraints liquidate projects and leave structures incomplete. The bust phase is characterized by declining income paid to factors, including labor, as well as a contraction in investment and consumption.

Although the framework of analysis and predictions of ABCT are for the most part unique, they share some common elements with more recent theories of the business

[1] For a discussion of Austrian macroeconomics more generally, see textbook treatments by Garrison (2001) and Skousen (2007).

[2] The step of identifying exogenous movements in credit and interest rates is critical to the exercise, since these variables move endogenously and hence are codetermined with other economic variables under study.

cycle.[3] Neoclassical macroeconomics, as illustrated in Lucas (1972), Kydland and Prescott (1982), or Barro and Gordon (1983), emphasizes the dynamic nature of economic decision making, the informational content embodied in prices, and, in Kydland and Prescott's case, the fact that a capital stock takes time to build. Additionally, New Keynesians such as Woodford (2003) draw a distinction between the market and Wicksellian rates of interest and show that the economy operates at a constrained first best when the market rate is equal to the Wicksellian rate. These elements are all embodied in ABCT. However, ABCT emphasizes the sequential nature of production and resource allocation between various stages of production. As ABCT holds many of the same features of modern macroeconomics, we believe that establishing the empirical relevance of features distinct to ABCT deserve to be fleshed out.

One problem facing empirical macroeconomists in the Austrian tradition is a shortage of data that corresponds to their theory. Business cycle accounting, as in Prescott (1986), focuses on the model's ability to match second moments of aggregate statistics like output, consumption, and investment. These statistics are readily available, reported at quarterly frequencies by the Bureau of Economic Analysis (BEA). In contrast, while ABCT makes predictions about what will happen to these aggregate statistics during the expansion and contraction, its distinctive features lie in what is happening to the relative prices and outputs of goods at various stages of production. For this, traditional aggregate statistics are entirely inadequate.

Fortunately, the Bureau of Labor Statistics (BLS) calculates separate producer price indexes for goods differentiated by their stage-of-process.[4] In addition, stage-of-process industrial production data is available from the Federal Reserve Board. Critical to note is that both these measures distinguish how far away goods are from their final use, which precisely captures the idea of a sequential structure of production. Moreover, these series have the added benefit of being available at a monthly frequency, thus making them amenable to studying the effects of monetary policy.

We have five variables we use to proxy for monetary policy: the federal funds rate (FFR), the monetary base, M1, M2, and a series of exogenous monetary policy changes constructed by Romer and Romer (2004). All of these measures are discussed in detail in the empirical portion of the paper. Using a structural VAR, we estimate a system of equations and use the estimated coefficients to trace out the impulse response functions of each stage-of-process variable to an exogenous monetary policy shock. Additionally, we trace out the effects of aggregate variables such as industrial production, unemployment, capacity utilization, and labor force participation.

Our results are sumarized as follows. First, an unexpected decline in the FFR leads to an increase in industrial production, capacity utilization, labor force participation

[3]Despite this uniqueness, ABCT can be presented using theoretical constructs familiar to all economists. This is a critical contribution of Garrison (2001) and is presented in the next section.

[4]Throughout we use "stage of production" and "stage-of-process" interchangeably to refer to a point in the structure of production. The former is used more frequently in Austrian capital theory and the latter is used by the BLS and Board.

and a decrease in unemployment. These results confirm the prediction of ABCT: previously unused and underutilized resources are drawn into production following credit expansion. The results for the relative prices and quantities are more ambiguous. Whether or not the late stage and early stage quantities and prices expand relative to their intermediate counterparts depends on the specific variable used to proxy for monetary policy, the time period under consideration, and what variables are included in the VAR. In many of the exercises, the response of variables on impact is opposite of what is predicted by the theory. However, across all specifications, the effects on relative prices and quantities are small. A 100 basis point decline in the FFR leads to no greater than a 0.5 % increase in any price or quantity index relative to another and the responses are estimated imprecisely. In contrast, aggregate industrial production expands by 2 % and has a tighter confidence interval. We conclude that evidence in favor of ABCT is, at best, mixed.

Despite the difficulty in taking theory to the data, several authors have evaluated ABCT quantitatively. Keeler (2001) and Mulligan (2002, 2006) document evidence consistent with ABCT. Young (2005), using job flow data at the industry level, shows that labor demand is sensitive to the interest rate, but notes that the magnitudes are not economically significant. Additionally, Young (2012), using the Total Industry to Industry Requirements data from the BEA, constructs a measure of "roundaboutness" for each industry and also for the economy as a whole. He shows that as the FFR fell below the interest rate recommended by the Taylor rule starting in 2002, the industries furthest back from final consumption experienced the biggest increase in prices and value added growth and subsequent to the bust in 2008 experienced the biggest decrease in prices and quantities. Finally, Carilli and Dempster (2008), after proxying for the natural rate of interest, show that deviations of the market rate from the natural rate Granger cause deviations in output. To the best of the authors' knowledge, no one has evaluated ABCT using the Federal Reserve Board and BLS stage-of-process data. Understanding how monetary policy affects relative prices and the structure of production, however, is vital to the Austrian theory and, consequently, our analysis fills a void in the literature.

The paper proceeds as follows. Section 2 elaborates on the Mises-Hayek theory and makes clear the main empirical implications of the model. Section 3 describes the data set and its advantages over previously explored data. The baseline empirical method is presented in Section 4, and the results in Section 5. Section 6 then presents several robustness checks, and finally, Section 7 concludes.

2 Theory

Our theoretical treatment of ABCT follows the textbook treatment by Garrison (2001) who illustrates the ABCT using tools familiar to economists. However, as mentioned in the introduction, the unique aspect of the theory is its treatment of the role of capital in the time structure of production. Capitalists bid for initial resources, e.g. land and labor, which they use to produce capital goods. This manufactured capital is combined with more land and labor to produce a new capital good and so on until a consumption good is produced. A good in process becomes more valuable over time for two reasons. First, more inputs are combined with the capital good which increases its attractiveness to consumers and second, because of a time discount. That is, since consumers value goods in the present more than those in the future, goods further back in the production process are more heavily discounted. This stage-of-process view depicts the economic process as inherently sequential.

Diagrammatically, the structure of production can be depicted in a Hayekian triangle [5] (Fig. 1a), named after Hayek who popularized the didactic device in *Prices and Production* (1935). The horizontal axis measures time and the vertical axis measures the value of the good in transit. The value of consumable output in the picture is the length of the vertical leg of the triangle. As Garrison notes, the horizontal axis can alternatively be described as measuring the stages of production, with the early stages being relatively far away from consumable output and later stages being closer to it. From a macroeconomic perspective, this second interpretation contains more insight. Early stage production is populated with industries such as primary goods manufacturing and resource extraction, whereas later stage production comprises the retail sector and other similar industries. The hypotenuse is linear and has a slope equal to one plus the market interest rate, i. While in reality the relationship is not linear and the slope is greater than $1 + i$, this abstraction does little harm to the analysis as the only point of interest here is the positive relationship of the slope with interest rates.

Figure 1b displays the market for investment and savings. The savings supply curve is an increasing function of the interest rate and the investment demand curve is a decreasing function of the interest rate. Market equilibrium occurs at the quantity $\boldsymbol{S} = \boldsymbol{I}$ and the interest rate, i_{eq}. Observe that the interest rate that emerges in the savings-investment market determines the slope of the Hayekian triangle. Also, it is worth noting that the interest rate that emerges in this undistorted economy is equal to the natural rate, which in equilibrium is equal to the consumer's rate of time discount, ρ. In Wicksell's or Woodford's terminology, the market rate is equal to the natural rate.

While the model is relatively simple, it describes the fundamentals of the economy we want to emphasize and facilitates comparative static analysis. For example, suppose the rate that consumers discount time decreases, to $\rho^{'}$ where $\rho^{'} < \rho$. This shifts the savings supply curve to the right, raising equilibrium investment and lowering the interest rate. Since the value of future goods rises relative to present goods, entrepreneurs invest in projects or industries that are further back in the structure of production. Or, to use Böhm-Bawerk's language, production becomes more roundabout. Consequently, the hypotenuse of the Hayekian triangle flattens and extends to the left. Since more resources are invested, the economy's rate of growth increases. Hence, the model easily captures the intuitive result: more patience today implies less immediate consumption, but more future consumption.

A virtue of ABCT is that the business cycle theory is a natural extension to the growth theory, which is also consistent with the Kydland and Prescott paradigm. In ABCT, the business cycle is induced through credit expansion by the monetary

[5] These figures are similar to what Garrison's (2001) presentation.

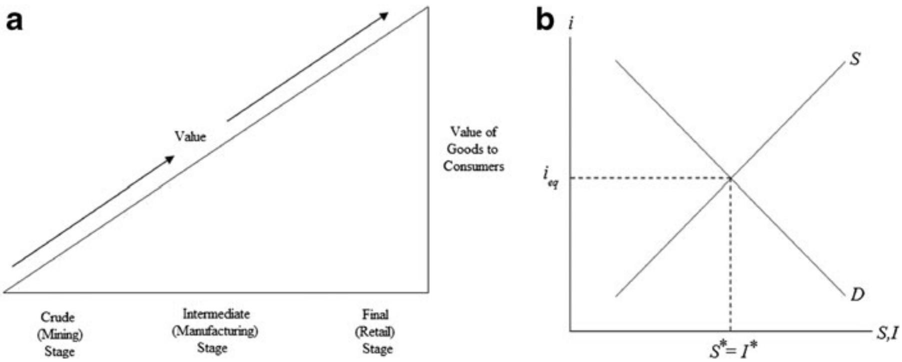

Fig. 1 **a** The Figure above Displays a Hayekian Triangle in an Undistorted Economy. **b** The Figure above Displays the Savings and Investment Market in an Undistorted Economy.

authority. Figure 2a, and b display what happens after a monetary expansion. The process begins when credit is injected in the savings and investment market, which is reflected in a rightward shift in the savings supply function in Fig. 2b and a decrease in the market interest rate from i_{eq} to i'_{eq} . Despite the increase in total credit available, consumers have not changed their intertemporal preferences and, in fact, want to save less of their income now that the market interest rate has decreased. On the other hand, entrepreneurs observing the lower market rate infer that consumers have become more patient implying that the profitability of supplying future goods is greater than supplying present goods. Since the highest order goods take the longest to mature into consumable output, they are most sensitive to the interest rate change. Consequently, the factor prices of the higher order goods are bid up and the production of more roundabout ventures commences. This is manifested by the hypotenuse in the Hayekian triangle flattening out as illustrated in Fig. 2a. The new, more roundabout ventures are what Mises referred to as malinvestment ([1949] 2008).

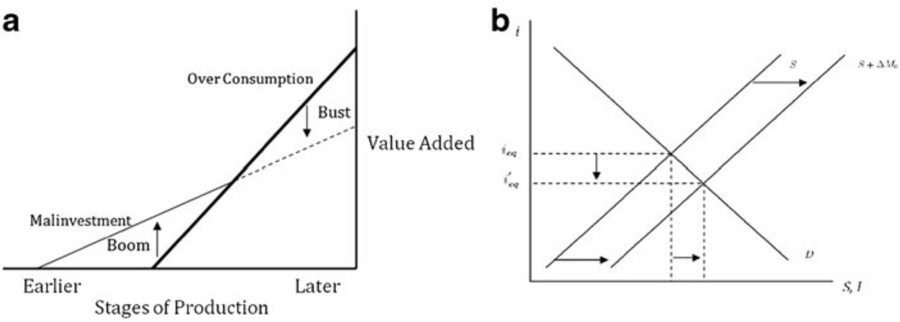

Fig. 2 **a** The Figure above Displays a Hayekian Triangle after a Monetary Expansion. **b** The Figure above Displays the Savings and Investment Market after a Monetary Expansion.

However, the story of the boom is not yet complete. Stimulated by the lower interest rate, consumers' demand for present goods increases relative to their demand for future goods. The increased demand for final goods increases prices and production in the least roundabout industries.This again is illustrated in Fig. 2a with a lengthening of the vertical leg of the Hayekian triangle and a rise in the slope of the hypotenuse. Mises (1949) termed the additional consumable output that comes from credit expansion overconsumption. Hence, the production plans of entrepreneurs are inconsistent with the demand vector of consumers. Cochran (2001) refers to this pattern as "dueling production structures". This policy induced growth, however, is unsustainable. As entrepreneurs realize that the demand for future products was illusory, they liquidate their projects. Since the demand for factors declines, payments to labor in the form of wages go down and consumption decreases. This economic contraction is generally referred to as the bust.

It is important to note that while there is over investment during the boom phase of the cycle, a distinguishing feature of the Austrian theory, as emphasized by Garrison (2001), is malinvestment. It is true that investment increases after credit expansion, but it is the type of investment that matters. The sectors that are most remote from final consumption, and hence the most sensitive to interest rate reductions, will experience the most malinvestment. As consumers demand more present goods, overconsumption complements the malinvestment. How do these processes occur simultaneously without clashing with aggregate resource constraints? There are at least three ways it is possible: resources that were out of the market can be enticed into the market, existing factors in the market can be used more intensively, and, finally, resources can be bid away from the middle stages of production. This last avenue is particularly important in this paper. Indeed, as Garrison (2004, p.331) emphasizes, the Hayekian triangle is being pulled at both ends with the middle stages being "raided" as a consequence.[6] The distorted Hayekian triangle, Fig. 2a, is convex to the origin as resources are being allocated away from the middle stages. The empirical implication is that, following a policy expansion, production and prices of the highest and lowest order goods should expand relative to those of the middle order. To the extent that entrepreneurs utilize previously employed factors more intensively, we expect utilization in the production of the highest and lowest order goods to expand more than in the production of middle order goods.

Distinguishing between what happens in the early, middle, and late stages of production is critical for the theory's interpretation. Without further restrictions on preferences and technology, one cannot say a priori if the prices and output of the latest stages will expand more than in the earliest stages. Whether higher order good prices expand more than lower order good prices, or the order in which the price increases occur, is inherently an empirical question. The only unambiguous prediction is that the middle stages should not see as big of an expansion following

[6]The point that overconsumption occurs in tandem with malinvestment should not be taken lightly. As Garrison (2004) notes, even Hayek exclusively focused on the malinvestment, or forced savings, aspect of monetary expansion entirely neglecting overconsumption.

a monetary shock. Indeed, if the tension at both ends of the Hayekian triangle is sufficiently strong, the middle stages might even contract. In the next section, we describe data on prices and production that distinguish between early, middle, and late stages of production.

3 Data description

ABCT emphasizes the sequential nature of production and how monetary intervention distorts intertemporal coordination. Data from the National Income and Product Accounts (NIPA) on gross domestic product (GDP), aggregate consumption, and aggregate investment, while potentially illuminating, do not permit this sequential interpretation. We believe, therefore, that data used to illustrate ABCT must emphasize this sequential structure, and as such, have constructed a data set from various sources that accomplishes this. The time span is from 1972 to 2011 and all data is available at a monthly frequency.

Our data set includes monthly observations of the FFR; indexes on industrial production and producer prices that distinguish industries by their stage-of-process; and aggregate measures of the unemployment rate, labor force participation, and capacity utilization. The data on the FFR is taken from the Federal Reserve Board's H.15 statistical release. The data on industrial production is from the Federal Reserve Board's G.17 statistical release. Industries are classified by their five digit NAICS codes and are partitioned into four groups. The groups for industrial production are: crude, primary, semi-finished, and finished. As the semi-finished and primary are almost perfectly correlated, we continue the analysis using primary as our measure of intermediate goods production.[7] The groupings are intended to capture the sequential nature of the structure of production.

The Federal Reserve Board determines an industry's classification based on input-output data from the BEA. Also, the corresponding indexes for production reflect the inputs of each industry. For instance, the industrial production (IP) index for final goods is the industrial input to final demand.

In addition to the industrial production data, the BLS publishes producer price indexes (PPI) for commodities distinguished by what the BLS defines to be "stage-of-process." With three categories for finished goods, intermediate goods, and crude goods, the stage-of-process PPIs are conceptually similar to the Federal Reserve Board's construction. There are, however, several subtle differences. First, the BLS distinguishes between commodities, not the industries that produce the commodities. Second, commodities can appear in more than one category so that each category is a weighted sum of commodities. For instance, gasoline is both a final consumption good and an input for commodity production in some manufacturing industries. Finally, the PPIs reflect the output prices of producers, not their input prices, whereas the Federal Reserve Board's index for industrial production reflects the production of the inputs for each stage-of-process. With these minor qualifications, we believe

[7] The series have a sample correlation of .9481.

these indexes provide a unique opportunity to illustrate ABCT and to understand how monetary shocks affect the structure of production and the relative prices between stages.

As Young (2012, p. 81) points out, the classification of industries into early and late stages of production is somewhat arbitrary. Rather, a strong understanding of ABCT requires us to consider the distance of goods from final consumption. Grouping goods or industries according to how close they are to finished products may not accurately reflect their distance from consumable output, and therefore, be misleading. By using an industry's Total Input Output Requirement as a proxy for roundaboutness, Young (2012) avoids this classification problem.

We believe our data, while having some limitations, offers several unique advantages. First, with the BLS price data, the unit of measurement is a commodity, not an industry. Changes in monetary policy directly affect the prices of goods and services which are then weighted and aggregated to changes in prices at the industry level. To the extent there is measurement error in the aggregation, using the BLS commodity data adds precision. Second, the BLS allows commodities to appear in multiple stage-of-processes. If one good is used as both a final output and an intermediate input the contribution of a price change affects both the finished and intermediate goods categories. Finally, both the IP and PPI stage-of-process data is available every month since 1972. Young (2012, p. 86–88) notes that PPIs are missing for some industries in various years. The missing data problem grows more severe as one extends Young's sample period, which starts in 1998, to earlier decades. In summary, while the data set at hand is not ideal, it offers several improvements to what has hitherto been considered and should be seen as complementing Young's (2012) classification.

Finally, we obtain measures of the monthly unemployment rate and labor force participation from the BLS and capacity utilization from the Federal Reserve Board's G.17 statistical release. These variables allow us to determine the extent to which more resources are drawn into the market and in what magnitude existing resources are used more intensively following a monetary policy shock.

4 Empirical strategy

As alluded to in our discussion of the ABCT, the distinctly Austrian predictions we aim to study relate to the dynamic impact of unforecasted policy innovations on stages of production relative to one another. To consistently identify the response of these relative prices and industrial production levels, our analysis follows the estimation techniques employed in Christiano et al. (2005) and estimates a series of structural VARs. Each structural VAR contains a measure of monetary policy, ratios of PPI by stage-of-process, and ratios of IP by stage-of-process. The key benefits of estimating a structural VAR are its explicit treatment of the endogeneity inherent in the simultaneous determination of the production and price variables and the minimal restrictions imposed on cointegrating relationships (Sims 1980). To evaluate the relative impact of monetary policy across stages of production, we consider the impulse response functions (IRFs) of these price and production ratios when exposed to a 100 basis point structural monetary policy shock. The PPI and IP ratios are defined as:

$$PPI_t^{CI} = \frac{Crude\ PPI_t}{Intermediate\ PPI_t}$$

$$PPI_t^{FI} = \frac{Finished\ PPI_t}{Intermediate\ PPI_t}$$

$$IP_t^{CP} = \frac{Crude\ IP_t}{Primary\ IP_t}$$

$$IP_t^{FP} = \frac{Finished\ IP_t}{Primary\ IP_t}$$

PPI_t^{CI} and PPI_t^{FI} capture the relative price indexes of crude to intermediate stages of production, and final to intermediate stages of production, respectively. The ratio of crude IP to primary IP and final IP to primary IP are captured by IP_t^{CP} and IP_t^{FP}, respectively.[8] By denoting middle stages of production as the common denominator, an increase in these ratios in response to policy shocks will support ABCT of shifting production technologies to from middle to earlier and later stages of production.

In addition to our stage-of-process ratios, we follow Bernanke and Blinder (1992) and use the FFR as our baseline measure of monetary policy. As Bernanke and Blinder note, the FFR carries policy information useful in forecasting real economic activity that is not found in any other monetary aggregate or market interest rate. As we are employing a novel dataset in testing this theory, we include a comprehensive robustness section which evaluates the dynamic impact of our stage-of-process ratios to innovations in three different proxies of monetary policy and a policy variable constructed by Romer and Romer (2004), as well as alternative identifying assumptions.

Although unexpected changes in the FFR can reasonably be understood as a monetary policy shock, ABCT emphasizes not changes in interest rates per se, but rather deviations in the natural and market rate of interest. Therefore, we could alternatively capture the monetary distortion if we knew the natural rate of interest. Since the natural rate is unobservable, researchers have used other variables such as the savings to consumption ratio and the growth rate in GDP to proxy for the natural rate.[9] The problem with these proxies is that they are not independent of monetary

[8]Note that we maintain the use of 'crude' and 'intermediary' as the middle stages of production to preserve the titles used by each dataset.

[9]See Carilli and Dempster (2008) for example.

policy, whereas the natural rate by definition is. So while the natural rate is proportional to the growth rate in GDP absent monetary distortions, it is not necessarily so when the growth rate in GDP is codetermined with the market rate. As individual's consumption patterns are determined simultaneously with the market rate, the same logic applies to the savings to consumption ratio.

One remaining concern before introducing our structural VAR is the potential for series non-stationarity to give rise to a spurious regression problem. In fact, Dickey-Fuller unit root tests on each of the stage-of-process ratios cannot reject the null hypothesis of a unit root with a trend, and simple OLS regressions of each variable on a single lag of itself indicate AR(1) coefficients not significantly different from 1. These results, summarized in Table 1, beckon us to estimate a model using first-differenced or detrended data after considering the potential for series cointegration. Were further tests to confirm the presence of cointegration, a common trend in the recent literature would suggest that we replace our VAR with a mean adjusting Vector Error Correction Model (VECM). However, as our principal concern is the dynamic response rather than point estimates, nonstandard standard errors are of little concern. In fact, a VAR with enough lags will produce "super" consistent estimates. In evaluating Johansen (1991) cointegration tests, which allow for the presence of multiple relationships, Trace statistics, shown in Table 1, find only one cointegrating relationship in one regression.[10] Recognizing the low power associated with Dickey-Fuller tests, we also estimate each VAR in levels and find minimal quantitative differences with the baseline specification. The results are presented in Appendix 1.

The fact that the ratios are neither cointegrated nor stationary implies that they will permanently diverge from each other. This behavior is consistent with sector specific technological change. Indeed, Greenwood et al. (1997), using data compiled by Gordon (1990), document that the ratio of prices of new equipment to consumption goods has a downwards trend through the second half of the 20th century, indicating that technological change has been faster in the investment sector. Hence, if technological change is faster in one stage-of-process sector than in another, neither the individual series, nor their ratio will be stationary. With this in mind, we log difference each ratio and present each series that follows as the growth rate of the relative indexes. As the FFR is left in percentage terms, IRFs carry the interpretation of "percent change to an 'x' percentage point change in the FFR".

The system contains 12 lags (ρ), or one year of monthly data, following standard monetary literature.[11] For a structural identification of FFR's impact on our various price and production variables, we appeal to the established monetary policy literature. A common theoretical restriction in monetary economics predicts that real variables will respond with a lag to interest rates, thus removing any contemporaneous effect of policy on real variables. To achieve this theoretical restriction in the

[10] Johansen cointegration tests find one cointegrating relationship in the regression that includes M2.

[11] See for instance Christiano et al. (1999).

Table 1 Summary of Series Tests

Test	Series	T-stat	P-Value	Test	Series	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Dickey-Fuller	PPI_t^{CI}	−2.1926	.2094	Johansen	Ratios with FFR	57.8985	33.5463	17.6806	7.4273	2.7732
Unit Root	PPI_t^{FI}	2.5239	.1104	Cointegration		(.3055)	(.5267)	(.5897)	(.5285)	(.0959)
	IP_t^{CP}	−1.4379	.5643		Ratios with M0	56.0873	30.8850	17.5210	5.6844	1.4897
	IP_t^{FP}	−1.3759	.5948			(.3745)	(.6726)	(.6015)	(.7324)	(.2223)
	FFR	−1.9842	.2939		Ratios with M1	61.9159	29.6320	16.2572	5.4355	0.2449
	$M0$	1.5290	.9994			(.1813)	(.7375)	(.6941)	(.7610)	(.6207)
	$M1$	.6452	.8574		Ratios with M2	93.9532	47.8040	23.5867	8.7073	3.2668
	$M2$	−2.3902	.1450			(.0002)	(.0506)	(.2184)	(.3932)	(.0707)

Table 1 summarizes the results of Dickey-Fuller unit root tests on each of the four logged ratios and the four monetary series. Each series was also estimated in an AR(1) finding coefficients not significantly different from one. The Johansen cointegration test evaluates the presence of multiple cointegrating relationships where r is the number of relationships. Each test is estimated on all variables included in the VAR. P-values are presented the parenthesis below the Trace Statistics. Critical Values for Trace Statistics: 69.8189, 47.8561, 29.7971, 15.4947, 3.8415 model, we order the FFR process last in our system of equations.[12] Thus, our five variable system appears as follows:

$$PPI_t^{CI} = \sum_{i=0}^{\rho} \beta_1^{CI} PPI_{t-i}^{CI} + \sum_{i=0}^{\rho} \beta_1^{FI} PPI_{t-i}^{FI} + \sum_{i=0}^{\rho} \beta_1^{CP} IP_{t-i}^{CP} + \sum_{i=0}^{\rho} \beta_1^{FP} IP_{t-i}^{FP} + \sum_{i=1}^{\rho} \beta_1^{FFR} FFR_{t-i} + \epsilon_t^{CI}$$

$$PPI_t^{FI} = \sum_{i=0}^{\rho} \beta_2^{CI} PPI_{t-i}^{CI} + \sum_{i=0}^{\rho} \beta_2^{FI} PPI_{t-i}^{FI} + \sum_{i=0}^{\rho} \beta_2^{CP} IP_{t-i}^{CP} + \sum_{i=0}^{\rho} \beta_2^{FP} IP_{t-i}^{FP} + \sum_{i=1}^{\rho} \beta_2^{FFR} FFR_{t-i} + \epsilon_t^{FI}$$

$$IP_t^{CP} = \sum_{i=0}^{\rho} \beta_3^{CI} PPI_{t-i}^{CI} + \sum_{i=0}^{\rho} \beta_3^{FI} PPI_{t-i}^{FI} + \sum_{i=0}^{\rho} \beta_3^{CP} IP_{t-i}^{CP} + \sum_{i=0}^{\rho} \beta_3^{FP} IP_{t-i}^{FP} + \sum_{i=1}^{\rho} \beta_3^{FFR} FFR_{t-i} + \epsilon_t^{CP}$$

$$IP_t^{FP} = \sum_{i=0}^{\rho} \beta_4^{CI} PPI_{t-i}^{CI} + \sum_{i=0}^{\rho} \beta_4^{FI} PPI_{t-i}^{FI} + \sum_{i=0}^{\rho} \beta_4^{CP} IP_{t-i}^{CP} + \sum_{i=0}^{\rho} \beta_4^{FP} IP_{t-i}^{FP} + \sum_{i=1}^{\rho} \beta_4^{FFR} FFR_{t-i} + \epsilon_t^{FP}$$

$$FFR_t = \sum_{i=0}^{\rho} \beta_5^{CI} PPI_{t-i}^{CI} + \sum_{i=0}^{\rho} \beta_5^{FI} PPI_{t-i}^{FI} + \sum_{i=0}^{\rho} \beta_5^{CP} IP_{t-i}^{CP} + \sum_{i=0}^{\rho} \beta_5^{FP} IP_{t-i}^{FP} + \sum_{i=1}^{\rho} \beta_5^{FFR} FFR_{t-i} + \epsilon_t^{FFR}$$

In this specification, β_i^j describes the partial effect of variable for j on each of the i where $i = 1, ..., 5$ and $j = CI,\ FI,\ CP,\ FP$, and FFR. To simplify notation, we can redefine this system into companion matrix notation by stacking variables such that $X_t = [PPI_t^{CI}, PPI_t^{FI}, IP_t^{CP}, IP_t^{FP}, FFR_t]'$ and $\epsilon_t = [\epsilon_t^{CI}, \epsilon_t^{FI}, \epsilon_t^{CP}, \epsilon_t^{FP}, \epsilon_t^{FFR}]'$. Each variable, except FFR, is in log difference form. The system can then be equivalently rewritten in companion matrix notation as:

$$A_0 X_t = \sum_{j=1}^{\rho} A_j X_{t-j} + \epsilon_t \tag{1}$$

[12]For a more in depth discussion of the proper variable orderings, see Bernanke and Blinder (1992) or Christiano et al. (1999)

In this equation, A_0 defines the coefficient matrix mapping variables to their ρ lags. By premultiplying each term by A_0^{-1}, this equation can be rewritten as:

$$X_t = \sum_{j=1}^{\rho} A_0^{-1} A_j X_{t-j} + A_0^{-1} \epsilon_t \tag{2}$$

In this new notation, A_0^{-1} takes the common interpretation of the "impact matrix" defining the contemporaneous response of variables to innovations. Given our system of 5 equations, A_0^{-1} can be written as:

$$A_0^{-1} = \begin{pmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,5} \\ a_{2,1} & a_{2,2} & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ a_{5,1} & a_{5,2} & \cdots & a_{5,5} \end{pmatrix}$$

Of particular interest in this analysis is the dynamic response of industrial production and price ratios to structural monetary policy shocks. In its current state, the system is underidentified. That is, there are multiple values of coefficients that will allow the above system of equations to hold exactly. In line with the aforementioned monetary literature, we employ a recursive identification scheme imposing a zero restriction on coefficients $a_{1,5}$ through $a_{4,5}$. That is, we impose that monetary policy does not have a "contemporaneous" impact on industrial production and prices. In terms of our A_0^{-1} matrix, we have:

$$A_0^{-1} = \begin{pmatrix} a_{1,1} & a_{1,2} & \cdots & 0 \\ a_{2,1} & a_{2,2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ a_{5,1} & a_{5,2} & \cdots & a_{5,5} \end{pmatrix}$$

The above system requires $\frac{n(n-1)}{2}$, or ten, restrictions to fully identify each of the equations. However, the four timing restrictions we place on the system allow us to uniquely determine all coefficients in the FFR equation giving us a structural interpration of monetary shocks on the four PPI and IP ratios of interest. As the remaining equations are underidentified, they are able to offer only a reduced form interpretation. In the remaining analysis, we thus restrict our discussion to the impact of our structurally identified monetary policy shock.

5 Results

Given our ratio construction presented in Section 4, evidence consistent with this theory should display an increase in each of the four ratios following an expansionary monetary shock. This would indicate that prices and production have a larger response to monetary policy shocks in the earlier and later stages of production than the middle stages. The results in this and the next section are summarized in Table 2, where we document the number of impulse responses that display the hypothesized

Table 2 Summary of Results

Identification (1)	Monetary policy variable (2)	Right sign on impact (3)	Significant after 10 periods (4)
Timing Restriction	FFR	3/4	1/4
	Monetary Base	2/4	2/4
	M1	2/4	0/4
	M2	1/4	1/4
Blanchard Quah	FFR	3/4	1/4
	Monetary Base	2/4	0/4
	M1	2/4	0/4
	M2	1/4	0/4

Table 2 summarizes the results of 40 different IRFs generated from the regressions in Sections 5 and 6. Two different identification techniques were used, each individually estimated with four different monetary policy variables. Ten period significance levels are considered using 80 % confidence intervals

sign in the period following the shock and if the response is statistically significant after ten periods.[13]

Figure 3 displays the five year impulse responses of our four price and IP ratios to a 100 basis point decrease in the FFR. Each figure includes 80 % confidence interval bands constructed using 1000 bootstrap iterations. The solid lines in each figure represent accumulated growth rates of the differenced series. On impact we see that only one of our four ratios, finished to intermediate PPI, displays behavior consistent with the ABCT, while the other three IRFs display either no significant change or evidence contrary to the theory. In the 30 months following the policy shock, finished to intermediate PPI displays behavior largely consistent with the theory, demonstrated to be significantly different from zero for a brief period after approximately nine months. While this early behavior is encouraging for the ABCT theory, the response is fairly small, with a maximum response of less than a 0.3 % increase.

Although PPI^{FI} displays impact behavior marginally consistent with the ABCT, the IRF for crude to primary IP is not as supportive. On impact, crude to primary IP falls sharply and displays declines significantly different from zero 12 months following impact. This downward trend continues through year five suggesting that intermediate stages of production expand more than crude stages following a monetary policy expansion. A similar picture is seen with the finished to primary IP ratio. In the 15 months following a policy expansion, very little relative change occurs with no movement significantly different from zero. After approximately 20 months, the ratio follows a downward trend suggesting again that intermediate goods output has a larger expansion following a monetary policy shock than finished goods output.

[13] A response is defined as statistically significant if it has the hypothesized sign the confidence interval does not contain zero.

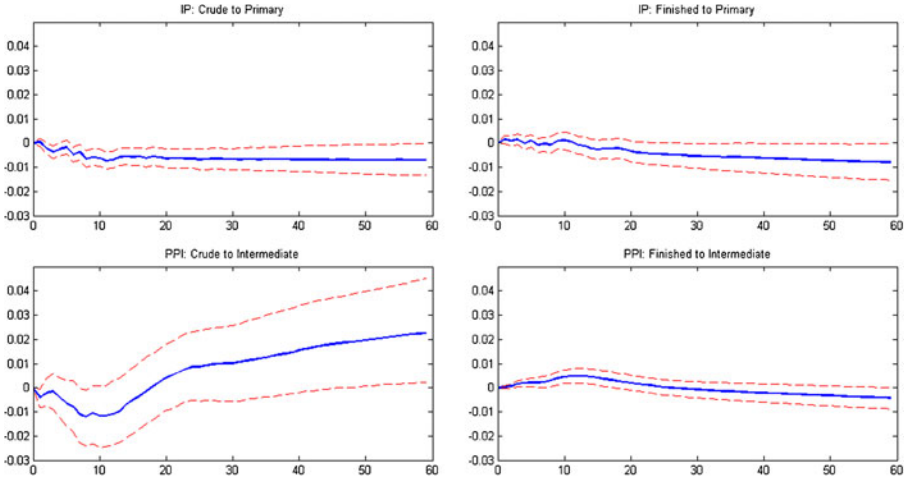

Fig. 3 Impulse Response to a 100 Basis Point FFR Shock: Timing Restriction. IRFs Represent a 100 Basis Point FFR Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with the FFR. *Solid Lines* Display Impulse Responses to a 100 Basis Point Shock to Monetary Policy. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

On impact, the crude to intermediate PPI ratio displays behavior contrary to what we would expect from ABCT. For the first 20 months, the ratio displays an increase in intermediate price growth over crude, suggesting that intermediate sectors are experiencing little of the capital flight predicted by theory. After 20 months, crude production displays behavior more in line with the ABCT and continues to grow at a rate larger than intermediate for the 40 months that follow.

It is critical to note that the results lack statistical significance. In each IRF, the 80 % confidence interval bands suggest that none of the four IRFs demonstrate impact or dynamic responses which differ significantly from zero for more than a few months. This point is particularly relevant when ABCT would otherwise rely on the large shifts in capital to drive business cycle dynamics. Rather, the shifts presented in Fig. 3 suggest that stages of production move in sync with one another following a monetary contraction. If anything, production expands most in the intermediate sectors, as shown by the decline in IP ratios, whereas the theory predicts resources should be leaving the middle and moving towards production of higher and lower order goods. Consequently, the resulting sectoral reallocation following a monetary policy shock is not supportive of ABCT.

To analyze the extent to which expansionary monetary policy draws previously unused resources into the market and induces more intensive use of existing resources, we consider an additional VAR including capacity utilization, labor force participation, the unemployment rate, and industrial production. As explained in Section 2, ABCT predicts that credit expansion leads to an extensive margin effect, more factors are drawn into production, and an intensive margin effect, existing factors are used more intensively. The results depicted in Fig. 4 largely support this hypothesis.

On impact, capacity utilization and labor force participation both increase, while the unemployment rate drops. The peak impact for each variable occurs between 15 and 30 months with unemployment dropping 0.08 percentage points, labor force participation increasing over 0.2 %, and capacity utilization increasing over 1.5 %. While these results are encouraging and are supportive of ABCT, it is the relative prices and production response which distinguish ABCT from other leading theories of the business cycle. In light of this, we are called to question whether our conceptual understanding of ABCT has neglected a major component responsible for business cycle dynamics. As with all general equilibrium models, multiple effects, often ones that are difficult to identify, are always at work. However, when considering the current analysis, the importance of relative price and production movements do not appear to be of first order importance over the course of the business cycle and are shown to be of little quantitative significance in our empirical investigation.

The case could be made that these aggregate indexes are still too coarse to study relative price and quantity changes seriously. We are dubious about this claim. First, although each index is comprised of many industries (in the case of IPs) or many commodities (in the case of the PPIs), they are grouped in a way that is quite amenable to the structure of production interpretation. Second, the key findings of the robustness section which follows are largely supportive of our main findings. That being said, higher quality data is always welcome, but researchers must work in the realm of what is technologically feasible.

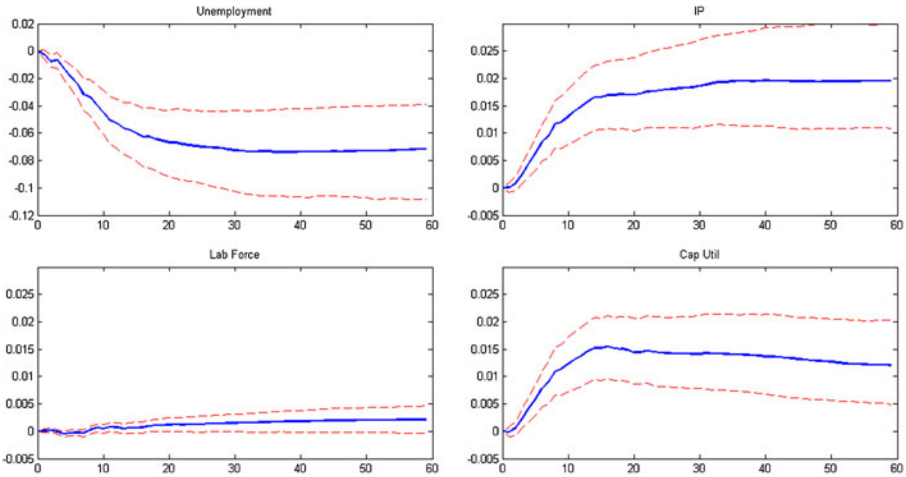

Fig. 4 Impulse Response to a 100 Basis Point FFR Shock: Timing Restriction with Aggregate Variables. IRFs Represent a 100 Basis Point FFR Shock to a Five Variable VAR with 12 Lags of each Variable. Variables include Unemployment, Industrial Production, Capital Utilization, and Labor Force Participation. Finally, we Proxy for Monetary Policy with the FFR. *Solid Lines* Display Impulse Responses to a 100 Basis Point Shock to Monetary Policy. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

6 Robustness

In any study of policy impacts, researchers face the difficult challenge of consistently identifying the impact of policy shocks on endogenously determined variables. Although monetary policy is by definition the province of central bankers, it is both reactionary and, through expectations, contemporaneously impacting economic activity. As a result, endogeneity issues obfuscate the consistent identification of structural shocks.

Acknowledging this difficulty, this section considers alternative means of identifying structural monetary shocks. To address concerns about the ability of the FFR to adequately proxy for monetary policy, we explore the use of alternative monetary policy measures. Alternative proxies for monetary policy include the monetary base, M1, and M2, as well as a series of univariate regressions employing the Romer dates of Romer and Romer (2004). Finally, we test the sensitivity of our results to our identifying assumptions by considering the long-run restrictions of the Blanchard and Quah (1989) (henceforth, BQ) decomposition. Our key findings are robust to each of these alternative identification strategies which suggests that the baseline VAR produces accurate, though controversial, evidence.

6.1 Alternative monetary policy measures

The monetary base, M1, and M2 series are key measures of the U.S. aggregate money supply commonly used as measures of changes in policy. In addition, the widely explored Romer dates from Romer and Romer (2004) characterize a series of dates capturing changes in monetary policy. In this section, we run the structural VARs using these alternative proxies of monetary policy. Again, we rely on timing assumptions to offer a structural interpretation to policy innovations and implement this strategy by ordering the monetary base, M1, M2, and the Romer date series last in each of the respective structural VARs. In Figs. 5, 6 and 7, we display three 60 period, or five year, IRFs displaying the response of our four price and production ratios in response to a one percent shock to the monetary base, M1, and M2.

The qualitative patterns of the price and quantity indexes display behavior slightly more consistent with ABCT, demonstrating growth in the ratios for crude to primary IP in response to both M1 and M2 shocks within 12 months. The crude to intermediate PPI ratio also demonstrates behavior weakly consistent with ABCT, displaying a decline on impact, but slightly increasing after approximately one year. However, for both M1 and M2 finished to primary IP and finished to intermediate PPI exhibit behavior largely predicted by ABCT for at least the first 24 months following an unanticipated monetary expansion. For the monetary base, we find support for ABCT in both crude to primary IP and finished to intermediate PPI, but weak counter evidence when considering finished to primary IP and crude to intermediate PPI.

While these results are mixed for ABCT, they again suffer from a lack of quantitative significance. The very small magnitudes of change as well as the statistical insignificance largely imply that the response to policy innovations is uniform across stages of production, though marginally larger for earlier and later stages of

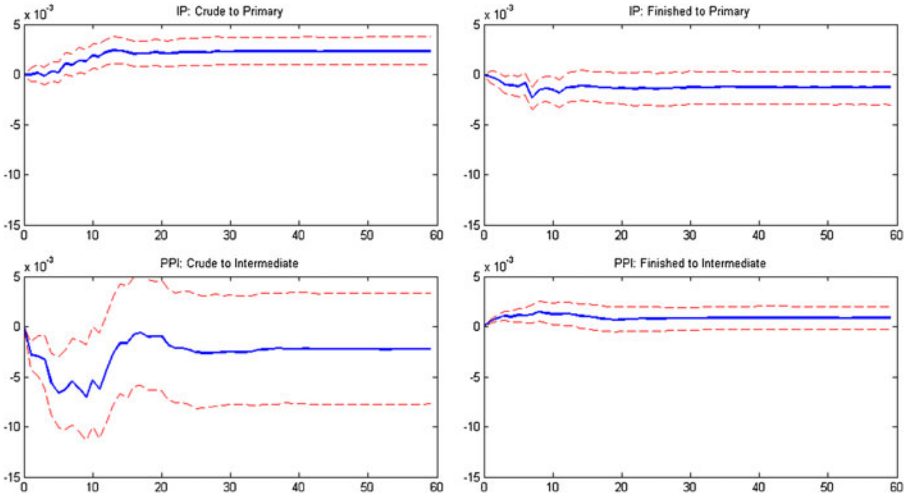

Fig. 5 Impulse Response to a 1 % Monetary Base Shock: Timing Restriction. IRFs Represent a 1 % Monetary Base Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with the Monetary Base. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

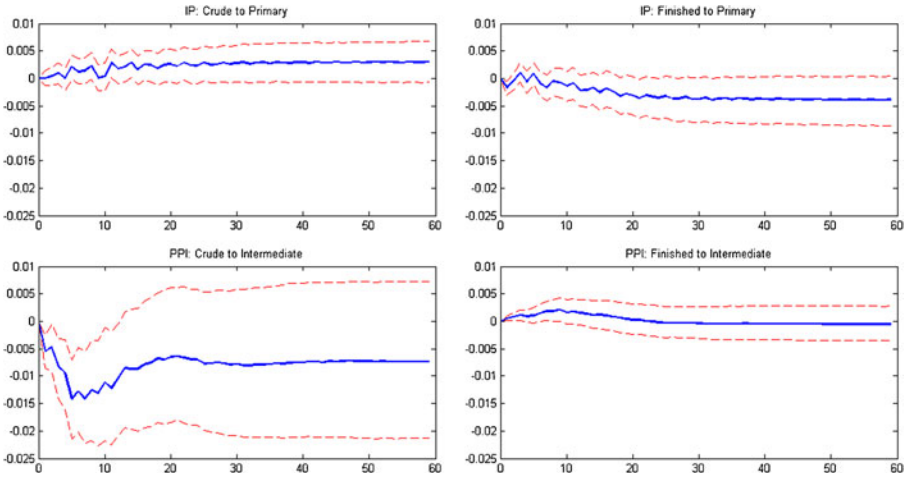

Fig. 6 Impulse Response to a 1 % M1 Shock: Timing Restriction. IRFs Represent a 1 % M1 Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with M1. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

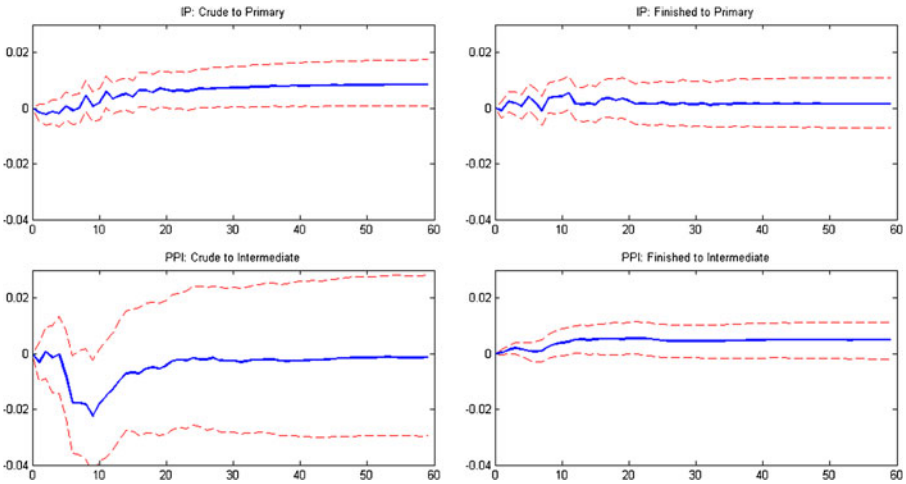

Fig. 7 Impulse Response to a 1 % M2 Shock: Timing Restriction. IRFs Represent a 1 % M2 Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with M2. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

production. However, these results are largely supportive of our main estimation, suggesting that FFR is a fair approximation of true monetary policy.

An alternative measure of monetary policy is offered by Romer and Romer (2004). Confronted with the problem of unidentified monetary policy changes, the Romers constructed a unique dataset of policy changes based off transcripts of Federal Reserve meetings. In addition, the authors use internal forecasts for inflation, unemployment and output growth rates to control for expectations of monetary policy makers. Mechanically, they regress the intended FFR on these expectation terms for several time horizons and save the residuals which serve as their monetary policy shock. The shock series, therefore, is purged of movements in the target unrelated to policy, as well as movements due to expectations of policy makers.

We analyze the data at a monthly frequency from the period 1972-1996.[14] Following the same specification used by Romer and Romer (2004), for each price and IP series we estimate an equation of the form:

$$\triangle y_t = \alpha + \sum_{i=1}^{N} \beta_i \triangle y_{t-i} + \sum_{i=1}^{J} \gamma_i v_{t-i} + \epsilon_t$$

[14]The Romers' data is available at a monthly frequency from 1969-1996 and is available from David Romer's website: http://elsa.berkeley.edu/~dromer/

where $\triangle y_t$ is the change in the (log) variable of interest from period $t-1$ to t and v_{t-i} is the constructed monetary policy shock at time $t-i$. Following Romer and Romer, we assume changes in the policy shock cannot have contemporaneous effects on output. Hence, the effect of a unit monetary policy shock at time t is γ_1, at time $t+1$ is $\gamma_2 + \beta_1\gamma_1$ and so on. For each IP and PPI series we trace out the dynamic effects of a 100 basis point negative monetary shock at time t. Throughout, we employ the common lag "specification" $N = J = 12$.

The results for the IP and PPI series are displayed in Figs. 8 and 9 respectively. The plotted points correspond to the cumulative response at each time horizon. As inflation and output respond positively to expansionary monetary policy, the results align well with an intermediate macroeconomic intuition. However, contrary to theory, primary goods production increases by more than the production of either the finished or crude goods. The peak responses are 4.12 %, 2.74 %, and 0.65 % for primary, finished, and crude goods respectively. The peak responses for each variable occur approximately two years after the shock.

For prices, the evidence is more mixed. Crude prices have a greater response on impact than the other two series and remain above intermediate goods for two years. However, the finished goods PPI increases by less than the intermediate goods index

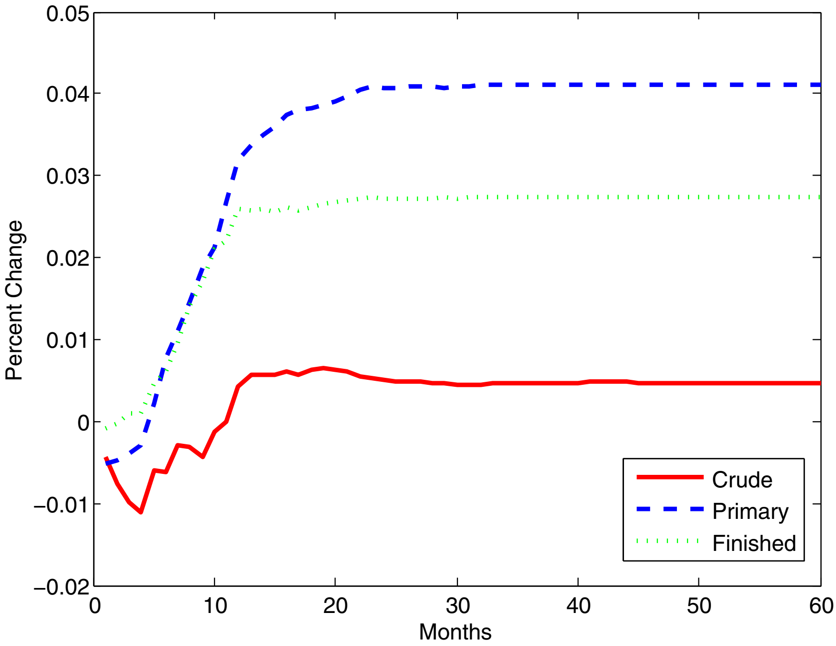

Fig. 8 IP Response to a 100 Basis Point Romer Monetary Shock. IRFs Represent each of the Stage-of-Process Industrial Production Variables to a 100 Basis Point FFR Shock as Measured in Romer and Romer (2004) in a 12 Lag System using Timing Restrictions to Identify the Structural Innovation. The *Solid Line* Displays the Crude Response while the *Dashed Line* Displays the Intermediate, and the Finely Dashed Line Displays the Finished Goods Response.

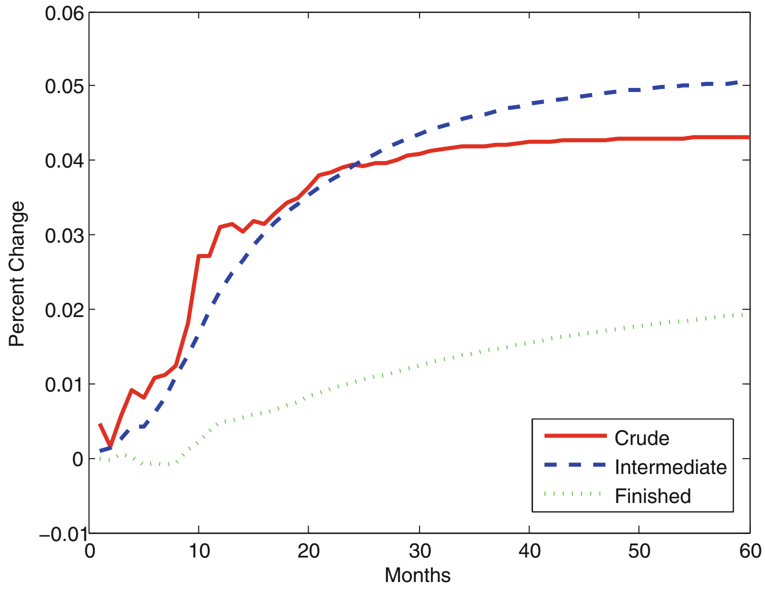

Fig. 9 Price Response to a 100 Basis Point Romer Monetary Shock. IRFs Represent each of the Stage-of-Process Price Index Variables to a 100 Basis Point FFR Shock as Measured in Romer and Romer (2004) in a 12 Lag System using Timing Restrictions to Identify the Structural Innovation. The Solid Displays the Crude Response while the *Dashed Line* Displays the Primary, and the Finely Dashed Line Displays the Finished Goods Price Response.

on impact and remains persistently below both indexes over the entire time horizon. Five years after the shock, the price index for final, crude and intermediate increases by 1.94 %, 4.31 %, and 5.05 % respectively.

6.2 Blanchard-Quah decomposition

Rather than employ impact restrictions as used by Sims (1980), BQ explore alternative means of obtaining a structural VAR, using *long run* restrictions on IRFs.[15] By first identifying both supply and demand shocks in a bivariate VAR, BQ appeal to the natural rate hypothesis and assume that demand-side disturbances have no long-run effects on real economic activity. Applying this notion to the present VAR, this implies that FFR shocks (and those of other monetary policy proxies used) will have no long-run impact on our industrial production and price ratios. In contrast, theory posits that productivity shocks impacting industrial production and prices will have permanent effects.

In addition to testing our baseline identification, the BQ decomposition also lends itself to ABCT. Theory predicts the real effects of monetary policy are changes in

[15]For examples, see Lastrapes and Selgin (1995).

the structure of capital and long-run accumulation of resources. While monetary policy is the catalyst for change, ABCT uses the real change in investment and capital accumulation as the driving force for growth.

To discuss this alternative structural identification, we begin by redefining our key equation in lag operator notation where $C_{ij}(L)$ are polynomials of lag operator L defined so that subcomponents $c_{ij}(L)$ define the individual coefficients of a variable's response to each structural shock contained in ϵ_t where ϵ_t is a vector of each of the n structural innovations $\epsilon_t = [\epsilon_{1,t}, \epsilon_{2,t}, ..., \epsilon_{n,t}]$. Here, we impose that $\text{corr}(\epsilon_{i,t}, \epsilon_{j,t}) = 0$ for any $i \neq j$. See Blanchard and Quah (1989) for a complete description of the estimation procedure. Before moving forward, we note each of the ratios are constructed in Section 4 to be non-stationary in levels, yet stationary in growth rates. As discussed in the data section, Dickey-Fuller unit root tests could not be rejected at the 10 % level, suggesting an explosive variance and the potential for spurious regression problems. The presence of these non-stationary series now presented in their stationary first differenced forms enables us to identify the permanent and stationary components of series growth and employ the BQ methodology.

To impose the BQ long-run restrictions, we essentially restrict the cumulative effect of a monetary policy shock on real variables to zero. In the context of the model presented above, this restriction implies:

$$\sum_{k=1}^{\infty} c_{15}(k)\epsilon_{5,t-k} = \sum_{k=1}^{\infty} c_{25}(k)\epsilon_{5,t-k} = \sum_{k=1}^{\infty} c_{35}(k)\epsilon_{5,t-k} = \sum_{k=1}^{\infty} c_{45}(k)\epsilon_{5,t-k} = 0$$

The IRFs using this estimation method for each of the monetary policy variables are presented in Figs. 10, 11, 12 and 13. We find qualitatively similar results to our baseline estimation with small and marginally significant impact effects of monetary policy shocks on each of the price and IP ratios. On impact, both IP crude to primary and IP finished to primary demonstrate responses largely consistent with ABCT. In addition, PPI finished to intermediate demonstrates behavior consistent with ABCT in the period following impact. While the magnitude of these results is not significantly different from zero, the direction is encouraging for ABCT. PPI crude to intermediate, however, demonstrates dynamic effects counter to theory demonstrating large and significant declines following the 100 basis point FFR contraction. The theoretical restriction of zero long run impact is clearly present, considering the null effect for 60 periods after impact.

In addition to the FFR shock, Figs. 11–13 display the impact of money base, M1, and M2 shocks on each of our ratios. The results are quite consistent across each of the policy variables, demonstrating impact responses counter to ABCT for IP crude to primary with varying levels of significance. However, the impact responses of PPI crude to intermediate and IP finished to primary are far more encouraging for the ABCT, demonstrating positive and occasionally significant results for the periods directly following impact.

While small differences between the timing and BQ identification exist, these results are largely supportive of our baseline estimation. Differences are small and

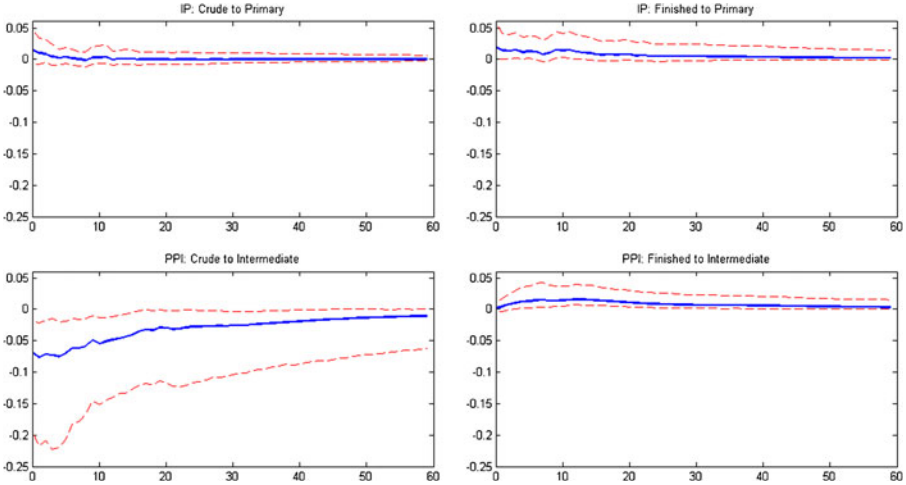

Fig. 10 Impulse Response to a 100 Basis Point FFR Shock: Blanchard-Quah Decomposition. IRFs Represent a 100 Basis Point FFR Shock to a Five Variable VAR with 12 Lags of each Variable using the BQ Decomposition. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with FFR. *Solid Lines* Display Impulse Responses to a 100 Basis Point Shock to Monetary Policy. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

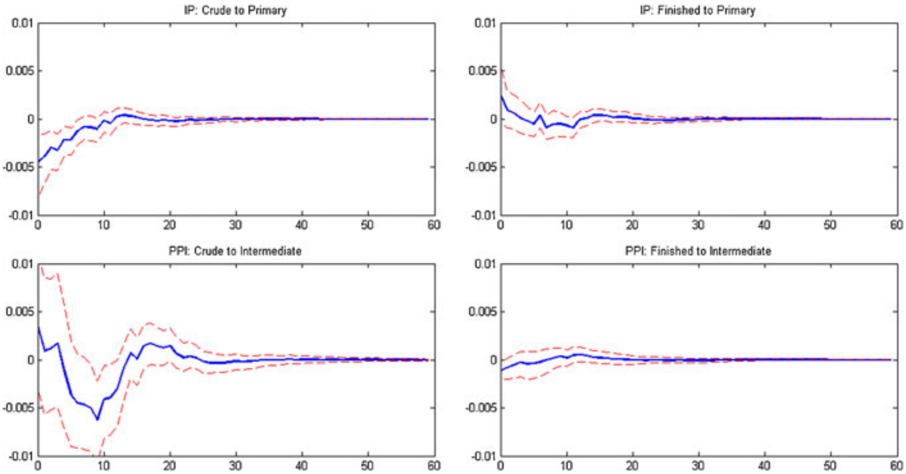

Fig. 11 Impulse Response to a 1 % Monetary Base Shock: Blanchard-Quah Decomposition. IRFs Represent a 1 % Monetary Base Shock to a Five Variable VAR with 12 Lags of each Variable using the BQ Decomposition. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy Monetary Policy with the Monetary Base. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

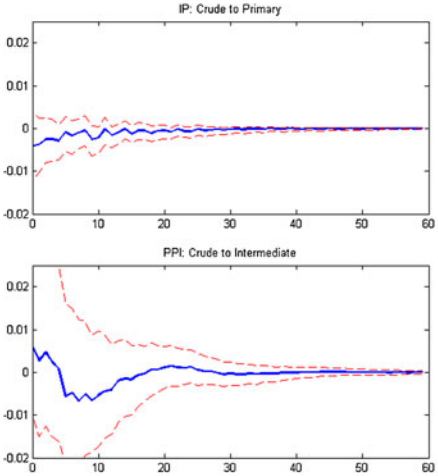

Fig. 12 Impulse Response to a 1 % M1 Shock: Blanchard-Quah Decomposition. IRFs Represent a 1 % M1 Shock to a Five Variable VAR with 12 Lags of each Variable using the BQ Decomposition. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy Monetary Policy with M1. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

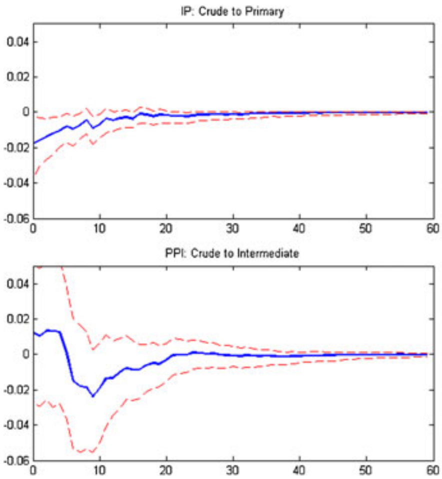

Fig. 13 Impulse Response to a 1 % M2 Shock: Blanchard-Quah Decomposition. IRFs Represent a 1% M2 shock to a Five Variable VAR with 12 Lags of each Variable using the BQ Decomposition. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy Monetary Policy with M2. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

seldom significantly different from zero for more than 10 periods. The results of these exercises substantiate our initial conclusion that there is limited evidence in favor of the relative price and quantity effects predicted by the theory.

7 Conclusion

ABCT makes distinct predictions concerning the movement of production technologies across stages of production following monetary policy innovations. Following unforecasted expansions in monetary policy, ABCT predicts growth in earlier stages as well as later stages of production, at the expense of intermediate stages. Additionally, the theory predicts that expansionary policy will be followed by new resources being drawn into production and existing resources being used more intensively. This paper offers an empirical investigation of this theory using a unique data set that includes information on prices and industrial production distinguishing industries and commodities by their stage-of-process, and comparing their relative movements following structural shocks in monetary policy.

Several results emerge from our analysis. First, there is clear evidence of new resources being drawn into the market and a higher utilization rate of existing resources. Second, the magnitude of the change in the ratios of relative prices and quantities across stages of production are, for the most part, reasonably small, lack statistical significance, and often do not have the sign predicted by the theory. These ambiguous results lead us to conclude that the empirical support of ABCT is, at best, mixed.

For macroeconomic researchers, our findings that the behavior of finer subindexes are statistically indistinguishable from their aggregate counterparts indicates that abstraction from microeconomic level details is not costly. On the other hand, the evidence is not as favorable for adherents to ABCT. ABCT makes predictions about relative prices and production after monetary policy changes, which is the theory's distinguishing characteristic. Indeed, just like New Classical and New Keynesian theories, ABCT predicts that aggregate output, investment, and employment rise following a central bank expansion. However, the unique contribution of ABCT is its predictions concerning the movement of relative prices and quantities. Consequently, to assess the merits of ABCT against competing theories, it is not sufficient to present evidence that is consistent with the predictions that are common across competing theories. Rather, the importance of discriminatory evidence is what motivated the use of this data set.

Despite the mixed empirical results, we believe insights from Austrian macroeconomics are valuable. A thorough appreciation of microeconomic foundations for macroeconomic models led to the neoclassical revival in the 1970s and continues today. Central to the revival was an appreciation for time, uncertainty, and especially the coordinating role of the price system, all of which are emphasized in ABCT. Future empirical research can use data relevant to ABCT, such as the series introduced in this paper, and modern empirical techniques to illustrate and test the propositions posited by the theory.

Appendix 1

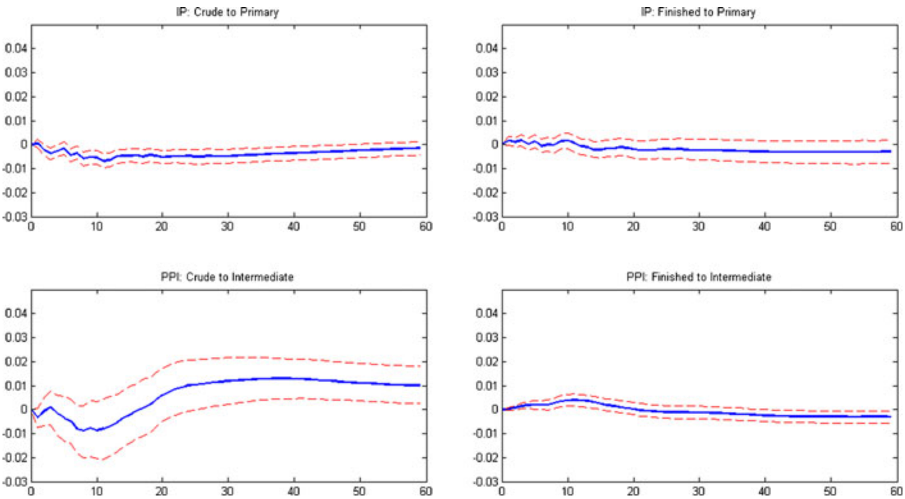

Fig. 14 Levels Impulse Response to a 100 Basis Point FFR Shock: Timing Restriction. IRFs Represent a 100 Basis Point FFR Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with the FFR. *Solid Lines* Display Impulse Responses to a 100 Basis Point Shock to Monetary Policy. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

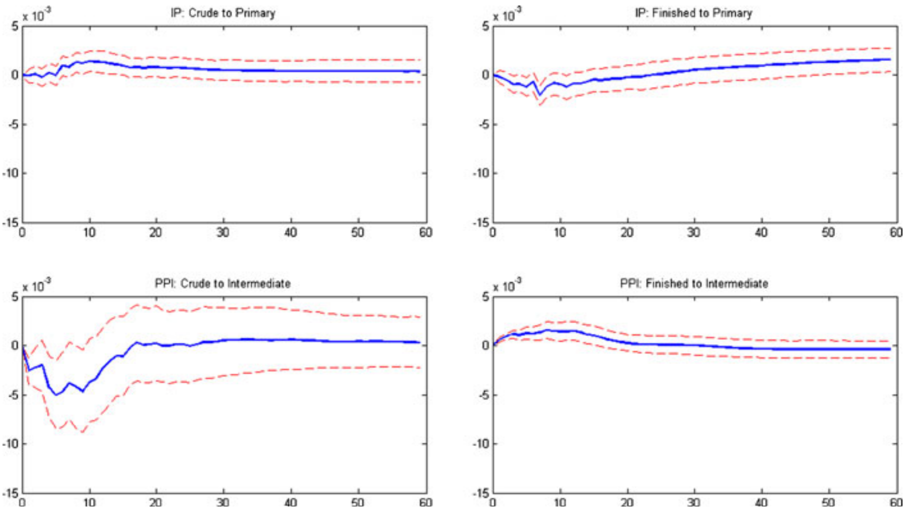

Fig. 15 Levels Impulse Response to a 1 % Monetary Base Shock: Timing Restriction. IRFs Represent a 1 % Monetary Base Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with the Monetary Base. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

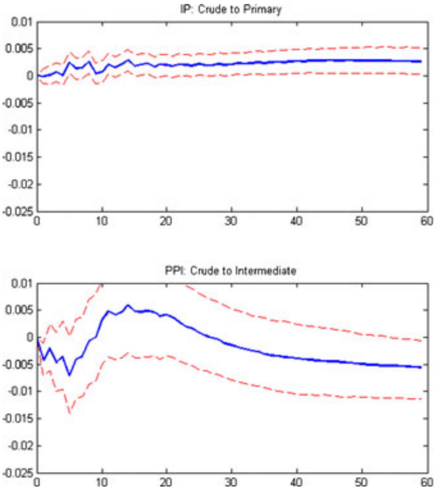

Fig. 16 Levels Impulse Response to a 1 % M1 Shock: Timing Restriction. IRFs Represent a 1 % M1 Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with M1. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

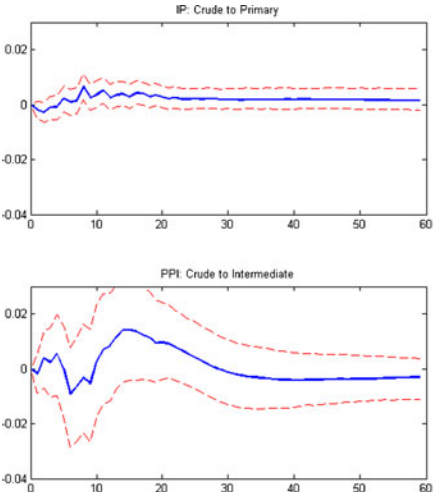

Fig. 17 Levels Impulse Response to a 1 % M2 Shock: Timing Restriction. IRFs Represent a 1 % M2 Shock to a Five Variable VAR with 12 Lags of each Variable. Variables Include Ratios of Crude to Primary and Finished to Primary Industrial Production, as well as Crude to Intermediate and Finished to Intermediate Prices. Finally, we Proxy for Monetary Policy with M2. *Solid Lines* Display Impulse Responses to a 1 % Monetary Policy Shock. *Dashed Lines* Display 80 % Confidence Intervals Generated by 1000 Bootstrap Iterations.

References

Barro, R.J., & Gordon, D.B. (1983). Rules, discretion and reputation in a model of monetary policy. *Journal of Monetary Economics*, *12*(1), 101–121.

Bernanke, B., & Blinder, A. (1992). The federal funds rate and the transmission of monetary shocks. *American Economic Review*, *84*(4), 901–922.

Blanchard, O., & Quah, D. (1989). The dynamic effects of agregate demand and supply disturbances. *American Economic Review*, *79*(4), 655–673.

Carilli, A., & Dempster, G. (2008). Is the Austrian business cycle still relevant? *The Review of Austrian Economics*, *21*(4), 271–281.

Christiano, L., Eichenbaum, M., Evans, C. (1999). Monetary policy shocks: what have we learned and to what end? In *Handbook of Macroeconomics* (Vol. 1A). Amsterdam; New York and Oxford: Elsevier Science, North-Holland.

Christiano, L., Eichenbaum, M., Evans, C. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, *113*(1), 1–45.

Cochran, J. (2001). Capital based macroeconomics. Recent developments and extensions of Austrian capital theory. *The Quarterly Journal of Austrian Economics*, *4*(3), 17–25.

Garrison, R. (2001). *Time and money: the macroeconomics of capital structure*. London: Routledge.

Garrison, R. (2004). Overconsumption and forced saving in the Mises-Hayek theory of the business cycle. *History of Political Economy*, *36*(2), 323-349.

Gordon, R. (1990). *The measurement of durable goods prices*. Chicago: University of Chicago Press.

Greenwood, J., Hercowitz, Z., Krusell, P. (1997). Long-run implications of investment-specific technological change. *American Economic Review*, *87*(3), 342–363.

Hayek, F.A. (1935). *Prices and production*. New York: Augustus M. Kelly.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, *59*(6), 1551–1580.

Keeler, J. (2001). Empirical evidence of the Austrian business cycle theory. *The Review of Austrian Economics*, *14*(4), 331–351.

Kydland, F., & Prescott, E. (1982). Time to build and aggregate fluctuations. *Econometrica: Journal of the Econometric Society*, *50*(6), 1345–1370.

Lastrapes, W.D., & Selgin, G. (1995). The liquidity effect: identifying short-run interest rate dynamics using long-run restrictions. *Journal of Macroeconomics*, *17*(3), 387–404.

Lucas, R. (1972). Expectations and the neutrality of money. *Journal of Economic Theory*, *4*, 103–124.

Mises, L. (1953). *The Theory of Money and Credit*. New Haven: Yale University Press. [1912].

Mises, L. (2008). *Human Action*. Auburn: Ludwig von Mises Institute. [1949].

Mulligan, R. (2002). A Hayekian analysis of the term structure of production. *Quarterly Journal of Austrian Economics*, *5*(2), 17–33.

Mulligan, R. (2006). An empirical examination of Austrian business cycle theory. *Quarterly Journal of Austrian Economics*, *9*(2), 69–93.

Prescott, E. (1986). Theory ahead of business cycle measurement. *Federal Reserve Bank of Minneapolis Quarterly Review*, *10*(4), 9–22.

Romer, C., & Romer, D. (2004). A new measure of monetary policy shocks: derivations and implications. *American Economic Review*, *94*(4), 1055–1084.

Sims, C.A. (1980). Macroeconomics and Reality. *Econometrica: Journal of the Econometric Society*, *48*(1), 1–48.

Skousen, M. (2007). *The Structure of Production*. New York: New York University Press.

Woodford, M. (2003). *Interest and prices: foundations of a theory of monetary policy*. Princeton: Princeton University Press.

Young, A.T. (2005). Reallocating labor to initiate changes in capital structures: Hayek revisited. *Economic Letters*, *89*(3), 275–282.

Young, A.T. (2012). The time structure of production in the US, 2002–2009. *Review of Austrian Economics*, *25*(2), 77–92.