

# INTEREST RATES, ROUNDABOUTNESS, AND BUSINESS CYCLES: AN EMPIRICAL STUDY

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JEL CLASSIFICATION: B53, C33, E23, E32, E43, E50

**ABSTRACT:** I show evidence of Austrian boom-bust dynamics in historical data on the production structure of 28 developed economies. I employ an autoregressive distributed lag model to find that policy-induced deviations from the natural rate of interest increases roundaboutness. This could instigate an unsustainable boom. Additionally, I find that early-stage industries have higher cyclical sensitivity than late-stage industries, consistent with Austrian time-value dynamics in the structure of production.

## INTRODUCTION

The influence of interest rates on the production structure of the economy is a key concept within the Austrian framework. In

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This paper is based on my MSc thesis. For valuable comments on earlier drafts of this paper including the thesis I thank Prof. Dirk J. Bezemer, Dr. Mark Skousen, Prof. Roger W. Garrison, and Prof. Lex H. Hoogduin. Last, I thank the editor and an anonymous referee for helpful suggestions that considerably improved this paper. All errors remain my own.



particular, interest-rate-setting central banks are deemed to be institutions distorting the market, often with a combination of artificially low interest rates and expansionary monetary policy. During the Great Moderation some economists claimed that the central banking puzzle was solved, but the 2008–09 global financial crises reignited the debate around this topic. A decade later, central banks are still dealing with the legacy of this crisis, for which the consequences are yet unclear. In this paper I provide an uncommon (to most policy-makers) though sensible view that could enrich the debate about the consequences of policy-induced monetary expansion inevitably followed by boom-bust episodes similar to the one in 2008–09. To substantiate, I attempt to quantify the difference between the natural rate of interest, defined by Wicksell ([1898] 1962) as the unobserved equilibrium price of savings and investments, and the market interest rate set by the central bank. Subsequently, I explore the effect of this interest rate gap on the production structure, or roundaboutness, of 28 OECD economies over the years 2000–14. Roundaboutness as originally pioneered by Menger (1871) and later expanded by Böhm-Bawerk (1891) explains the indirectness and lengthiness of the process in which consumption goods are created. To capture the roundaboutness of an economy, I make use of the Gross Output (GO) metric pioneered by Skousen (1990, 2015, 2018). GO measures the combined value of all stages of production in the economy.<sup>1</sup> By dividing GO by GDP, one obtains a measure which increases (decreases) with a lengthening (shortening) of the production process. Böhm-Bawerk (1891) argues that more indirect processes *ceteris paribus* are associated with more economic progress and increased productivity. However, expansionary monetary policy is prone to instigate an unsustainable growth path. A low-interest rate policy stimulates investments which are not profitable under the natural rate, leading to malinvestment and overconsumption, in turn leading to boom-bust dynamics (Mises [1912] 1953; Hayek 1932, 1933; Garrison 2002, 2004).

This paper contributes in three ways. First, I construct a unique data set on Gross Output for 28 OECD countries over the years

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<sup>1</sup> While Skousen has formalized and widely promoted the concept of GO, it is wholly based on Rothbard's (2009, 396–403) distinction between the Keynesian "net expenditure / income approach" and the Austrian "gross expenditure / income approach".

2000–14. Second, I develop a proxy measure for interest rate gaps combining the Taylor rate, the consumption-investment (CI) rate and the long-term interest (LTI) rate. Austrian theory suggests that a larger interest rate gap positively influences the roundaboutness of the economy.

Third, I explore this theoretical relation in autoregressive distributed lag (ARDL) models. There are a few studies which examine this relation for individual countries (e.g. Mulligan 2006; Carilli et al. 2008), but the present paper is the first to explore the average relation for a large number of developed economies.

The results are consistent with Austrian business cycle theory (ABCT). I find that larger interest rate gaps are indeed associated with greater roundaboutness of the economy. Additionally, I find that this effect is stronger in a subsample of the five most roundabout of 65 industries than on average (though only to prolonged gaps, of more than one year, and when using a Taylor-based proxy for the interest rate gap). In comparison, the association is three to five times weaker in a subsample of the five least roundabout industries. Also, these additional analyses are in line with Austrian business cycle theory, which implies that more roundabout, hence more capital intensive industries, should respond more to interest rate changes (Skousen, 2015, 273–304). An important qualifier of this analysis is that the results are based on average effects found in historical data—they are not forecasts, nor descriptions of individual countries. The findings do suggest that on average in 28 OECD countries during the years 2000–14, the association of empirical proxies for the interest rate gap and roundaboutness were just as suggested in Austrian business cycle theory.

Apart from the scientific contribution, the study has clear societal relevance. The effects of expansionary monetary policy are obviously of great and very topical concern. Monetary mismanagement is fundamental to macroeconomic dysfunctions in the intertemporal allocation of resources (Dobrescu et al. 2012). Policy makers as well as academics will benefit from an analysis that adds the Austrian perspective to what is primarily a mainstream debate on the direction of monetary policy.

This paper is further organized as follows. Section 2 provides a survey on the current knowledge about ABCT, both theoretical and

empirical. Special attention is given to the theory and application of the Hayekian triangle. In section 3, I present an econometric model to estimate the responsiveness of (sectoral) roundaboutness to the interest rate gap and in section 4 I explain how the dataset is constructed. Section 5 provides results including model variations and a sensitivity analysis. Section 6 concludes the paper and offers some suggestions for future research.

## **1. AUSTRIAN BUSINESS CYCLE THEORY TO DATE**

### **1.1 Roundaboutness and Capital Theory**

The conventional measure for the size of the economy is the gross domestic product (GDP). Skousen (2010, 2015, 178–85) lists the shortcomings. GDP is a net output measure of finished goods and services, which leaves out intermediate production activity and business spending in the supply chain. Each of these expenditures is the result of entrepreneurial decision making, which in turn influences the rest of the economy. Entrepreneurs do not start or expand activities based only on value added. If we are to construct an empirical proxy for ‘how the economy is doing,’ it should capture the totality of spending decisions. A gross measure, not a net measure, satisfies this criterion. Note that because of this theoretical motivation, there is no double counting problem, a common objection to the GO concept. In a system of accounts, intermediate business to business transactions are just as relevant and real as economic activity linked to final goods and services (Jorgenson et al. 2006). As Skousen (2015) puts it, “GO is the top line and GDP is the bottom line of national accounting, ..... [and both] are of equal importance” (p. xix). I will operationalize this below by using both GO and GDP in an empirical proxy of roundaboutness.

The degree of roundaboutness in an economy, a concept of central theoretical importance in Austrian theory, can be proxied by the value of GO relative to GDP. With increasing roundaboutness, increasing amounts of savings-induced capital are employed to sustainably increase the capital intensity and efficiency of the intertemporal production process. The aggregate of all these processes, with varying degrees of efficiency, forms the time structure of production of the economy. Hayek (1932) further developed the time structure

of production into a schematic triangular construct, known as the Hayekian triangle. The improved version of this triangle as designed by Garrison (2002) is nowadays used to describe the successive processes of capital (goods) accruing value from the original means of production, through the resource phase, up to the final stage where they are transformed into consumption goods. Capital is heterogeneous: it moves up along the hypotenuse as working capital, which, at the final stage, is consumed (in)directly or put into use as fixed capital, aiding future working capital forward in the production process.

The concept of time is of crucial importance to capital heterogeneity and its impact on economic booms and busts. Garrison (1990) shows that the neoclassical stock-flow approach, which claims production and consumption are simultaneous, is unrealistic. The theory assumes all subjective factors in the production process as fixed through time and view the capital stock as a 'permanent fund.' This process may *appear* simultaneous, but when one refrains from the temptation to generalize capital as an attempt to formalize it, one notes that a fundamentally uncertain future by definition means the production process is subjective and not fixed through time. The subjective factors in this process are typically entrepreneurs who make decisions about how and what capital formation takes place (Mises [1949] 1998). These decisions are based on the interpretation of the economic outlook and are by no means based on clairvoyant expectations. Inherently, a fraction of the entrepreneurs always either misjudges the economic climate or is downright unfortunate, and the macroeconomic impact of these events is relatively small. However, when there is a broad central-bank-induced misconception about future demand due to misaligned—investor vs. consumer—(time) preferences, the fraction of bad decision-making significantly increases, which causes a consumption boom and a severe capital misallocation at the same time. Were it for neoclassicals, capital could easily be moved elsewhere at no cost. In reality, however, the liquidation, the adjustment and the redirection of wrongly allocated capital is a painful process.

## 1.2 Interest Rate Effects and Financial Sector Dominance

The main culprit for capital misallocation is the distortive effect of monetary expansion on the natural rate of interest. An excessive

increase of the money supply sends conflicting signals to investors and consumers creating a wedge between the savings and investment equilibrium on the loanable funds market. The expansion lowers the interest rate and creates two virtual equilibria: (1) consumers see the lower rate as an incentive to spend more *now*, while (2) investors are led to believe that consumers will spend more *later*. This illusion of a surplus of available savings for early-stage investment purposes has been called ‘forced savings’ by Hayek (1932) and is wholly equivalent to Mises’s ([1949] 1998) malinvestment. Garrison (2004) shows graphically how these forced savings affect the structure of production leading to a ‘dueling’ production structure (Cochran 2001).

The rational expectations hypothesis is often brought up as a refutation of this theory (e.g. Wagner 1999, Cowen 1997). Evans and Baxendale (2008) nullify this argument introducing entrepreneurial heterogeneity in a prisoner’s dilemma setting based on an article by Carilli and Dempster (2001). This use of the prisoner’s dilemma illustrates the limits of rationality. Many investors may well be aware of the fact that a policy-induced credit expansion increases nominal rather than real savings. Some may even be aware of the boom-bust consequence. However, since central authorities have the sole right of issuing legal tender, investors (but even more so, banks) can externalize the cost of recessions towards (other banks and) the taxpayer (Hayek 1933). In fact, profit-maximizing investors *must* increase their lending or their competition will (King 2016). The incentive for the individual makes the collective system worse off. Even though investors might thus be aware of unsustainable lending practices, they are competitively forced into this behavior. In the words of Carilli and Dempster (2001), ‘banks need *not* be fooled or tricked into increasing lending’ (p. 324) but their customers *will* be fooled. The majority of customers is ignorant and just seeks the lowest price forcing banks to compete while unaware of the unsustainable system. Even the educated customer is ‘bribed’ into foolish behavior—in a macroeconomic sense—because he will otherwise get outcompeted by the ignorant ones (Garrison 1989, Block 2001). The result is that economic agents (no matter their background) are ‘pushed up’ the boom phase of the cycle towards margin lending because strategic behavior induces them to. This imposes clear restraints on the impact of rationality. The ‘search for yield’ systematically moves lenders towards riskier investments.

Bloomberg (2016) writes: “Credit fund managers who, having largely sat out on the recent rally in junk-rated debts, now find themselves *forced* to re-enter the fray after underperforming the wider market” (emphasis mine). Additionally, Hendrickson (2017) finds that investment by firms at lower interest rates is increasingly more prone to coordination failures, adding to risk and uncertainty.

Mulligan (2013) argues that the ABCT shows resemblance with Minsky’s (1992) Financial Instability Hypothesis (FIH) in which a first mover advantage is present for lenders (borrowers) extending (taking on) more credit (debt). This means that the prisoner’s dilemma works over both the extensive and intensive margin: who is in/out, and who is first? Thus not only does excessive credit expansion lead to moral hazard, it also allows an adverse selection problem to materialize since margin lending (borrowing) lures ‘bad’ entrepreneurs and non-creditworthy borrowers into the market (Evans and Baxendale 2008). Moreover, informational cascades (or Cantillon effects) increase investor-consumer inequality due to a knowledge gap which in turn is amplified through the adhesive power of the financial sector (Howden 2010). Resource misallocation along the structure of production shifts focus and resources away from the real sector. Entrepreneurial knowledge is extracted by the financial sector leaving the real sector at a serious knowledge disadvantage on how to align consumer demands along the structure of production.

### 1.3 Empirical Approaches to the Structure of Production

According to Lewis and Wagner (2016) Austrian macro theory suffers from an underdevelopment in the use of empirics to support theory. Expanding on those, or developing new ways to empirically support theory would, according to the authors, make Austrian macro theory able to compete with mainstream dominance. Examples of empirical Austrian research are Mulligan (2006), Fillieule (2007), Young (2012) and Cachanosky and Lewin (2014) amongst others. Not surprisingly, they all relate to the Hayekian triangle in one way or another.

Mulligan (2006) for instance finds that lowering the interest rate below sustainable market rates provides a short-term boost to consumption and investment, but has a decreasing effect in the long run. This is in line with the ABCT. Fillieule (2007) mainly analyzes the

goods-in-process structure of production and finds that a lower time preference is followed by a lengthening of the production structure in which the profitability of earlier stages relatively increases. While this provides some concrete results, he uses a formalized form of the average production structure concept of Böhm-Bawerk (1891) to counter the infinite-stages problem. Economists like Garrison (1981) argue this to be a futile attempt to quantify a series of subjective numbers into one value. An alternative approach by Cachanosky and Lewin (2014), though also based on an average production period, uses the economic value-added (EVA®) literature which allows them to ‘reframe roundaboutness and interest rate sensitivity into financial terminology’.<sup>2</sup> In their review of the triangle, they effectively determine that, due to its nature, empirical research is prone to subjective judgment because of the very structure of the triangular concept. The authors do endorse the approach taken by Young (2012) who qualitatively examines the impact of interest rate deviations on the aggregate roundaboutness of the Hayekian triangle rather than on specific stages. Young’s analysis of the 2002–09 US structure of production is relatively simple but elegant. He develops a ‘total industry output requirement’ (TIOR) as an indicator for roundaboutness. I will expand on his work by taking this indicator to a country level. The breadth of my dataset allows me to assess the economy-wide roundaboutness of 28 countries. This generalization, however, comes at the cost of not being able to assess individual country characteristics. Based on regression analysis, I expect similar results to match with ABCT in the sense that the production structure of an economy will expand with a larger interest rate gap.

## 2. METHODOLOGY

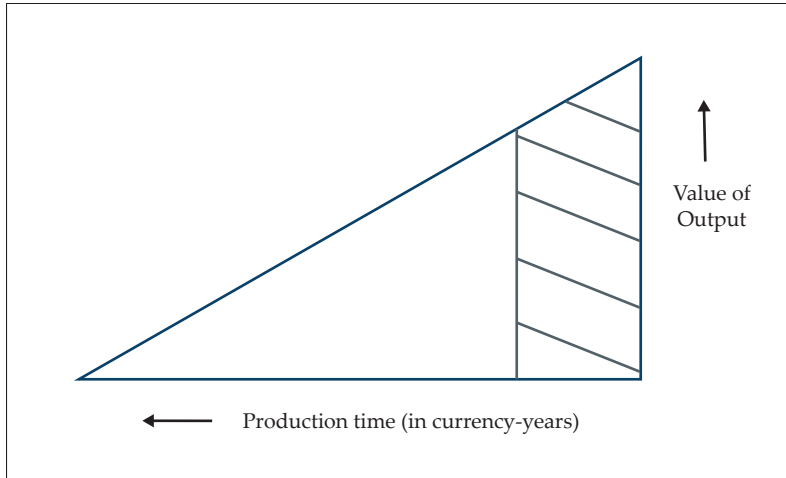
I use cross-country regression analysis to examine whether there are generalizable effects of a larger interest rate gap on the roundaboutness of economies. I approach roundaboutness by creating a similar metric to Young’s (2012) TIOR which I call TEOR, or, the ‘total economy’s output requirement’. The TEOR of a specific country reflects the amount of gross output required from its domestic industries both directly and indirectly to deliver a currency unit of final output.

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<sup>2</sup> EVA® is a registered trademark of Stern Stewart and Co. (Cachanosky and Lewin 2014).



**Figure 1. A Simplified Hayekian Triangle**



The TEOR is defined as the ratio of gross output to final output (excluding foreign inputs for simplicity). To illustrate, in Figure 1 I present the Hayekian triangle with intermediate and final outputs. The TEOR value is the surface of the triangle (total gross output) divided by the shaded part (final output). Formally, consider that the economy consists of an array of industries indexed by  $i=1, \dots, N$ . Industries process intermediate (capital) goods yielding value added, denoted by  $\sum_{i=1}^N VA_i = VA$ , equal to final output (Garrison 2002). According to the Bureau of Economic Analysis, value added equals the difference between an economy's gross output and the cost of its intermediate inputs.<sup>3</sup> Industry gross output is denoted by  $X_i$ .

Total gross output is then given by

$$(1) X = \sum_{i=1}^N X_i$$

from which the TEOR can be derived as,

$$(2) \frac{\sum_{i=1}^N X_i}{\sum_{i=1}^N VA_i} = \frac{X}{VA} = \frac{\text{Gross output}}{\text{Value added}} = TEOR = \text{roundaboutness}$$

<sup>3</sup> See [https://www.bea.gov/faq/index.cfm?faq\\_id=1034](https://www.bea.gov/faq/index.cfm?faq_id=1034).

By definition, a relative increase in the production of intermediate goods increases TEOR. Assuming no monetary intervention, such a situation occurs when the average relative time preference of consumers decreases. Conversely, a relative increase of final output decreases TEOR which occurs when the average relative time preference of consumers increases. This allows TEOR to function as an interpretation of roundaboutness which is an important step in the empirical analysis of ABCT.

To measure the interest rate gap, I take the difference between a country's market interest rate (i.e. the short-term interest rate) and the natural interest rate. I proxy the latter following the original equation of Taylor (1993):

$$(3) r_t = \pi_t + \alpha_\pi (\pi_t - \pi_t^*) + \beta_Y (Y_t - \bar{Y}_t) + r_t^*$$

To simplify, I follow Taylor's (1993) rule of thumb to attach 0.5 weights to  $\alpha$  and  $\beta$ . I specify  $(Y_t - \bar{Y}_t)$  as the output gap  $Y_t$  which then yields,

$$(4) r_t = \pi_t + 0.5(\pi_t - \pi_t^*) + 0.5 Y_t + r_t^*$$

where  $r_t$  is the market interest rate that *should be* targeted,  $\pi_t$  is the current core CPI inflation rate,  $\pi_t^*$  is the desired inflation rate and  $r_t^*$  is the estimated value of the equilibrium real interest rate. The latter's estimations differ (Yellen, 2015) but I will follow Young (2012) and Taylor (1993) by setting it to 2 percent. A desired inflation rate of (close to) 2 percent is commonly accepted in OECD countries hence I equally standardize that rate. Natural rate estimation then follows:

$$(5) r_t = \pi_t + 0.5(\pi_t - 2) + 0.5 Y_t + 2$$

Combining this with the *actual* market rate, the interest rate gap is calculated as:

$$(6) r_t - r_a = r\_gap$$

The baseline regression then estimates the relation between the interest rate gap and roundaboutness:

$$(7) \log TEOR_{c,t} = \beta_{1c} + \beta_{2r\_gap_{c,t}} + \beta_{j_{c,t}} x_{j_{c,t}} + \varepsilon_{c,t}$$

where  $c$  and  $t$  respectively denote country and year. To recognize country heterogeneity, I control for time-invariant country characteristics in the intercept. Absolute differences between the two

interest rates are useful because it allows for assessing the impact of sustained gaps. A production structure might not instantly adjust to a one-off deviation. Negative gaps ( $r_t < r_a$ ) pose no problems to the expected outcome since its reverse equally holds true (Rosen and Ravier, 2014).

Given the likelihood of a dynamic relationship and potential autocorrelation, I include lags of both variables and assume (trending) stationarity. Additionally, interest rates changes—often piecemeal—are subject to the Cantillon mechanism resembling distributive effects. Similarly, TEOR is also dependent on its previous values since economic growth is equally gradual. The possibility to detect the movements of both variables could be improved using quarterly or monthly data which I unfortunately do not have.

A consequence of using the ARDL model is the violation of the assumption that the dependent variable is uncorrelated with the error term—ARDL implies autocorrelation. To eliminate this, I include sufficient lags of both variables such that lagged errors can be excluded. The optimal lag amount minimizes the Akaike and Bayes information criteria. I further control for demographics since this is known to push down interest rates (Rachel and Smith, 2015; Carvalho et al., 2016). The ratio of old population (age > 65) to total population captures this effect.

To assess the elasticity of specific production stages to interest rate gaps, I follow Young (2012) and average respectively the five most roundabout (MR) and least roundabout (LR) industries into two ‘TIOR’ rates. The goal of creating these two averages is to examine the difference in cyclical sensitivity between early and late stages. Last, the CI and LTI proxy function as alternative to the Taylor proxy. Interest rate gaps are:

$$(8) r\_gap_{CI} = \frac{\text{consumption (as \% of GDP)}}{\text{investment (as \% of GDP)}} - r_a$$

$$(9) r\_gap_{LT} = r_{LT} - r_a$$

The CI proxy is inspired by Carilli et al. (2008) but modified following Rothbard (2009) who points out that the proportion between consumption and investment (rather than saving) reflects individual time preferences.

### 3. DATA

One of the main contributions of this paper is to construct a unique data set on Gross Output for 28 OECD countries over the years 2000–14.<sup>4</sup> Underlying data has been retrieved from the World Input-Output Database (WIOD) 2016 release (Timmer et al. 2015, 2016). Specifically, I extracted annual data from 28 different National Supply and Use Tables (SUTs) corresponding to the OECD countries. The database is classified according to the ISIC Rev. 4 and its tables are based on SNA 2008. To retrieve GO per country, I use ‘total intermediate consumption’ (column labeled ‘INTC’) for GO—at basic prices—from the Use tables. This includes value added (at basic prices) plus intermediate inputs adjusted for taxes less subsidies. I calculate GDP as total value added of all industries using the same source (taxes and subsidies excluded).

Necessary data for the Taylor-rate equation are collected from several sources. The realized market interest rates per annum are retrieved from the OECD database on short term interest rates, with the exception of rates for Hungary, Japan and Slovenia which were collected from AMECO. Core CPI rates and output gaps are respectively from the OECD and AMECO database. Data on the old population ratio is from the World Bank Development Indicators (WDI). I calculated the consumption-investment interest rate proxy using data from the WDI. Specifically, I use Gross Capital Formation (as percent of GDP) and Final consumption expenditure (as percent of GDP). The long-term interest rate is proxied by OECD government bond data except for Estonia, Slovak Republic, and Slovenia, which are from the AMECO database. Some years are missing: Czech Republic (2000), Estonia (2011–14), Korea (2000), Mexico (2000, 2001), Poland (2000), Slovenia (2000, 2001).

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<sup>4</sup> See Appendix A for a country overview.

**Table 1. Descriptive Statistics Including Variable Definitions**

Variables		Mean	Std. Dev.	Min	Max	Obs
TEOR	Overall	2.114676	.225896	1.710082	2.783239	420
<i>Total economic output requirement</i>	Between		.221732	1.732869	2.563897	
	Within		.0592171	1.893153	2.381133	
MR	Overall	7.971532	13.18658	2.64948	176.28	420
<i>Average TIOR of five most roundabout industries</i>	Between		5.706832	3.704307	30.14698	
	Within		11.9334	-15.7166	160.7456	
LR	Overall	1.288068	.1144785	1.087378	1.666902	420
<i>Average TIOR of five least roundabout industries</i>	Between		.1090287	1.097168	1.502767	
	Within		.0401903	1.193027	1.452203	
r_gap (in %)	Overall	.7418975	2.556133	-9.586836	11.44673	420
<i>Natural-to-market gap (Taylor rate proxy)</i>	Between		1.078422	-2.782372	2.814299	
	Within		2.325873	-11.53267	10.52899	
r_gap (in %)	Overall	.130709	2.936574	-15.55812	7.641661	420
<i>Natural-to-market gap (Consumption-investment proxy)</i>	Between		1.878827	-4.743801	2.893584	
	Within		2.282854	-12.67127	5.715418	
r_gap (in %)	Overall	1.459914	2.007454	-5.03416	21.92432	409
<i>Natural-to-market gap (Long term interest rate proxy)</i>	Between		1.019766	-5.889171	4.866493	
	Within		1.738077	-5.182894	18.51774	

MR and LR are calculated using underlying data from the national SUTs of the WIOD. One exception is made for Japan, where one of the five least roundabout industries, household activities, was calculated in a seemingly inconsistent way—I used the sixth least roundabout industry instead. According to Rosen and Ravier (2014), a new business cycle began around December 2000, hence I use 2001 as the base year to determine MR and LR.

The panel data are strongly balanced ( $N = 420$ ). For further descriptives, see Table 1. Most variables are complete except for the LTI proxy. TEOR is relatively normally peaked but slightly skewed rightwards. MR has a few large outliers which might bias the estimators—normalizing solves some of the skewness. LR is more normally distributed but somewhat skewed to the right. The MR–LR distributional difference makes sense from a theoretical perspective. The included 65 industries roughly follow a Pareto-like distribution where MR industries are relatively more dispersed and further from the mean than LR industries. Taking the average from

a sample of 10 industries to mitigate this difference barely affects LR but greatly affects MR potentially risking diluting its elasticity to the interest rate gap.

## 4. ANALYSIS

### 4.1 Baseline results

I use a panel fixed effects baseline ARDL regression with clustered robust standard errors to counter heteroskedasticity in the error variance. A unit root test rejects non-stationarity. To determine the optimal lag amount for TEOR and the interest rate gap I add to both variables up to 5 lags and subject each specification to an AIC/BIC test. This suggests an ARDL(1,0) process to be optimal for modeling the relationship. A manually performed RESET test confirms that the model does not suffer from omitted variable bias. To check whether serial correlation has been eliminated, I compare the ARDL(1,0) process to eight other variations and again subject them to an information criteria test. To visualize the variations:

$$\begin{array}{l}
 \text{Process variations:} \\
 \text{AIC results:}
 \end{array}
 \begin{bmatrix}
 \text{ARDL}(1,0) & \text{ARDL}(1,1) & \text{ARDL}(1,2) \\
 \text{ARDL}(2,0) & \text{ARDL}(2,1) & \text{ARDL}(2,2) \\
 \text{ARDL}(3,0) & \text{ARDL}(3,1) & \text{ARDL}(3,2) \\
 -2081.046 & N/A & N/A \\
 -1934.602 & N/A & -1937.585 \\
 N/A & N/A & -1792.445
 \end{bmatrix}$$

The model comparison shows that the ARDL(1,0) process remains to be the best fit. BIC results correcting for observation loss—due to added lags—points in the same direction. Note that it is not a certainty that autocorrelation in the error term is completely eliminated, but it is as much as possible.

**Table 2. Comparison of the relationship between TEOR and the interest rate gap based on three different proxies. The dependent variable is logTEOR.**

VARIABLES	(1) ARDL(1,0) Taylor rate	(2) ARDL(1,1) Consumption- investment rate	(3) ARDL(1,0) Long term interest rate
logTEOR [t - 1]	0.69093*** [0.05210]	0.72308*** [0.04817]	0.72267*** [0.05344]
r_gap (in %)	0.00112** [0.00047]	-0.00576*** [0.00124]	-0.00120 [0.00107]
r_gap (in %) [t - 1]		0.00544*** [0.00096]	
old population (% of total)	0.00217** [0.00085]	0.00170* [0.00090]	
Constant	0.19562*** [0.03978]	0.18256*** [0.03899]	0.20841*** [0.03968]
Observations	392	392	386
R-squared	0.57060	0.64766	0.56270
Adj R-sq increases with r_gap	YES	YES	YES
Number of Countries	28	28	28
Country FE	YES	YES	YES

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.10

To compare the Taylor-based ARDL process to the other two proxies, I run through the exact same process to determine the most optimal amount of lags for both specifications. Results suggest an ARDL(1,1) and ARDL(1,0) process for respectively the CI and LTI proxy. A comparison of the TEOR responding to all three proxies is provided in Table 2. Column 1 shows that a Taylor-based interest rate gap of 1 percent significantly results in a 0.11 percent more roundabout economy, *ceteris paribus*. Thus, GO increases with 0.11 percent as compared to final output, a difference in difference effect. The second column displays contradicting results and with a zero net effect does not support ABCCT, whereas results in column 3 are insignificant altogether. I want to make two additional remarks. First, I left out the control variable for the LTI proxy because demographic effects are already captured by the long term government bond interest rate (Rachel and Smith, 2015). Second, note that I included

a test whether the adjusted R-squared in fact increases upon adding  $r\_gap$  (and its lags) to the specification, indicating its relevance.

## 4.2 Cyclical Sensitivity and Country Conditions

I now substitute TEOR with MR and TR and run through the same procedure for lag and model optimization. Significant outcomes are for MR combined with the Taylor proxy and for LR combined with the CI and LTI proxy. Other variations return insignificant results. I provide the significant results in Table 3. Interestingly, the MR response to the interest rate gap is negative for the contemporaneous year but positive for its first lag. A prolonged ( $t > 1$ ) interest rate gap of 1 percent results in a net positive effect on roundaboutness of around 0.65 percent.

**Table 3. Comparison of the average TEOR to stage-specific TIORs. DEPVAR refers to the relevant dependent variable specified below the column number.**

VARIABLES	(1)	(2)	(3)	(4)
	TEOR ARDL(1,0)	MR ARDL(1,1) Taylor rate	LR ARDL(1,0) Consumption- investment rate	LR ARDL(1,0) Long term interest rate
logDEPVAR [t – 1]	0.69093*** [0.05210]	0.52544*** [0.10867]	0.77843*** [0.05966]	0.85397*** [0.03667]
$r\_gap$ (in %)	0.00112** [0.00047]	-0.01851* [0.01027]	0.00214*** [0.00061]	0.00138* [0.00072]
$r\_gap$ (in %) [t – 1]		0.02501** [0.01087]		
old population (% of total)	0.00217** [0.00085]	0.06881*** [0.02025]	0.00057 [0.00107]	
Constant	0.19562*** [0.03978]	-0.17822 [0.37298]	0.04879*** [0.01282]	0.03767*** [0.00907]
Observations	392	392	392	386
R-squared (within)	0.57060	0.38242	0.71256	0.71703
Adj R-sq increase with $r\_gap$	YES	YES	YES	YES
Number of Countries	28	28	28	28
Country FE	YES	YES	YES	YES

Robust standard errors in brackets

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$



The responsiveness to an interest rate gap of the most roundabout industries is 5 times larger than that of the least roundabout industries (0.14–0.21 percent), providing the gap persists during at least two successive years. This suggests that more remote industries are as expected more elastic to interest rate changes. The CI and LTI proxy are inherently less volatile and might therefore explain the non-significant responses of MR. Conversely, the same reasoning might apply to LR estimations.

Finally, I check whether the baseline Taylor-based TEOR results are robust to specific country conditions (table not reported). In particular, I include three additional control variables on their own, and as interaction with the interest rate gap. First, I look at the growth rate of financial depth and proxy this with the growth rate of liquid liabilities as a percentage of GDP (King and Levine 1993). Second, I use R&D expenditures growth (as percent of GDP) to proxy capital intensity. Third, I use stock market capitalization growth (as percent of GDP) to determine the impact of financial sector development. A developed financial sector is generally associated with economic growth and better resource and capital allocation (Allen and Gale 2000, Levine 2002). For every addition, I re-run the lag and model optimization process to determine the most optimal ARDL specification. None of the three added control variables, nor their interactions with the interest rate gap, significantly changes the earlier results from Table 2.

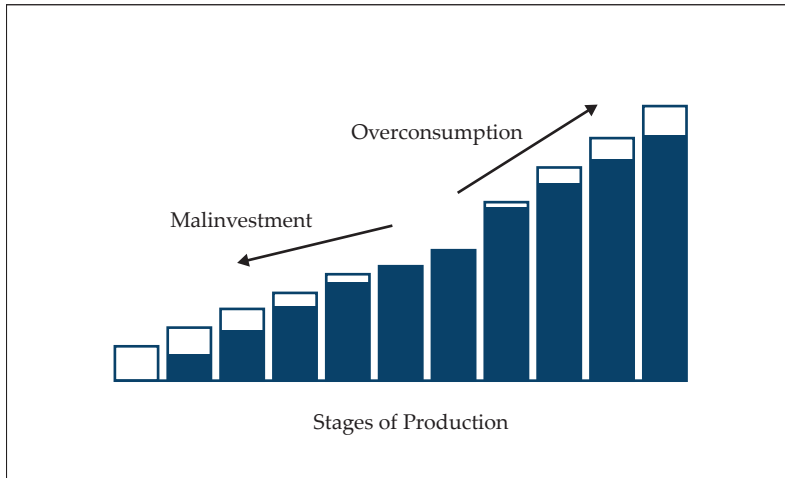
## 5. DISCUSSION AND CONCLUSION

### 5.1 Discussion of the Results

A positive relationship is found between TEOR and the Taylor-based interest rate gap. The outcome is both significant and economically relevant. Over the observation period, GO shows a relative growth rate of 0.11 percent to GDP for every percent increase in the interest rate gap. This translates approximately into a 0.22–0.33 percent change in GDP terms (i.e. TEOR rate\*  $\Delta$ GO). For a small (big) country like Belgium (United States) this means *hypothetical* capital misallocation of EUR 920 million (USD 34 billion) in 2014. In the upswing of a business cycle, capital misallocation accumulates over the years and pushes the economy

beyond its maximally attainable production possibilities frontier until the inevitable correction sets in (Garrison 2004). A back-of-the-envelope calculation provides further color to this scenario by suggesting more capital misplacement results in deeper downturns (see Appendix B).<sup>5</sup>

**Figure 2. The Dueling Hayekian Triangle**



Source: Garrison (2004).

Policy-induced interest rates suggest an unsustainable increase in the capital-intensity of the economy potentially initiating an Austrian boom-bust cycle. Artificially low rates provide a short-term boost to both final output and gross output. ABCT predicts the latter effect to be dominant and this is indeed observable in the results. Early stage industries respond up to 5 times stronger to (prolonged) interest rate gaps than late stage industries. Early stage—more roundabout—industries act more pro-cyclical and more volatile

<sup>5</sup> I note two caveats here. The amounts mentioned for capital misallocation are hypothetical in the sense that it is impossible to know what share of capital is easily redirected during economic recovery and what part is plainly wasted. It is thus equally impossible to accurately determine the accumulated stock of misallocated capital the moment before a boom turns into a bust. The amounts are merely provided to give an impression of the magnitudes potentially affecting the production structure of an economy.

due to time-value of money effects (Skousen 2015). Interestingly, MR industries also require a multi-lagged model suggesting they are also more sensitive to delayed interest rate effects. The fact that the average TEOR response is smaller than the lower-bound LR response may seem odd. A possible explanation for this behavior is that the average response is likely similar to a response from middle stages. In a 'dueling' Hayekian triangle setting, middle stages are relatively negatively affected due to misallocated capital (Cochran 2001, Garrison 2004). This results in a kink in the hypotenuse (see Figure 2). The potential relatively negative effect of the middle stages might have pulled down the economy wide average industrial response to an interest rate gap.

ABCT is particularly consistent with Minsky's (1992) FIH which describes that extended periods of economic prosperity lead to under-evaluation of market risk inducing firms and other market participants to increase investment (Mulligan, 2013). While this process of progressive overleveraging is endogenous, the Austrian monetary expansion is exogenous. However, both mechanisms are prone to the influence that expansionary monetary pressure exerts on inflating the boom. Increasing roundaboutness due to interest rate gaps closely resembles a Minsky-like period of euphoria. Quite literally, due to misperception of risk variability and adjustment costs (i.e. price signals), entrepreneurs increasingly engage in plan revisions to further expand their business (Mulligan, 2013). This decreases productivity and leads to wasteful spending (Dobrescu et al., 2012).

## 5.2 Limitations and Suggestions for Future Research

Based on the constructed dataset, I put forward some suggestions I chose not to pursue in the current paper. First, different natural rate proxies could be used to calculate the interest rate gap. Labauch and Williams (2003) provide such an alternative, albeit technical, as well as Keeler (2001) who uses a term spread technique, which however should be slightly adjusted to meet the critique of Carilli et al. (2008). Second, the Taylor rate could equally be established differently. Here, both the proposition of Yellen (2015) to modify the real equilibrium interest rate or a non-generalized inflation rate to match specific countries' past and present inflation targets could be followed.

Others interested in this topic but rather on a country level could combine the methodology of Young (2012) and the dataset of the present paper. This could yield 27 additional qualitative country-specific studies on production structures and would greatly expand the knowledge of Austrian business cycles in each of those countries. Additionally, these studies could be extended with an empirical VAR analysis including a Granger-causality check á la Carilli et al. (2008), which is quite laborious for panel data. If employing VAR, longer time series would then be desirable (e.g. by adding more years or finding quarterly or even monthly data).

Furthermore, the methodology of this paper could be used for within country panel analysis on the industrial level—each industry has its own TIOR. Data for this can be retrieved from the national SUTs of the WIOD (Timmer et al., 2015). In fact, the Young analysis could even be applied to a singly industry within or cross-country.

### 5.3. Conclusion

The empirical analysis of this paper confirms that Austrian boom-bust dynamics are economically relevant and do not just remain ABCT artifacts. I have employed an autoregressive distributed lag model to analyze historical data related to the production structure of 28 developed economies. I found that policy-induced deviations from the natural rate of interest increases roundaboutness and could instigate an unsustainable boom. Additionally, I found that early stage industries have higher cyclical sensitivity than late stage industries confirming the importance of time-value dynamics in the structure of production (Skousen 2015). I used three natural rate proxies the significance of which varied across the different dependent variables. The Taylor proxy applies best to average economic as well as early stage roundaboutness, while the alternative proxies are a better fit for late stage roundaboutness. Even though these differences can be explained to a certain extent, further research on these causes is warmly welcomed.

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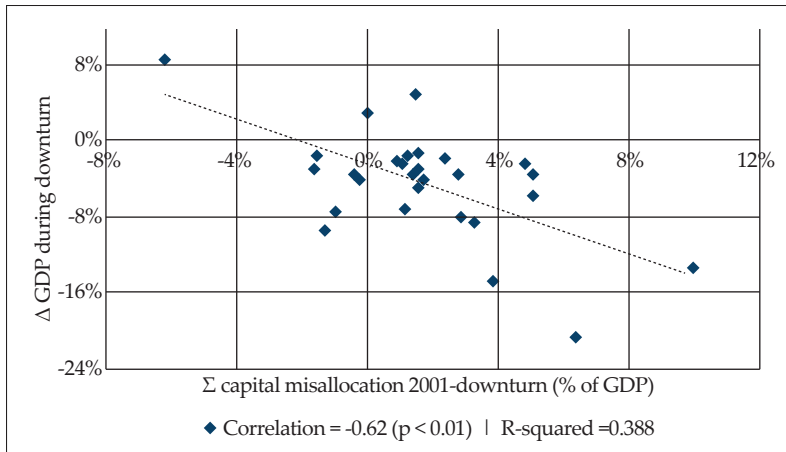


### Appendix A. Overview of Countries Included in the Dataset

Countries	Currency used in database		
	USD	EUR	Other (in brackets)
EU 28	Estonia, Greece, Portugal, Slovak Republic, Slovenia	Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Spain	Czech Republic (CZK), Denmark (DKK), Hungary (HUF), Poland (PLN), Sweden (SEK), United Kingdom (GBP)
Other	United States		Australia (AUD), Canada (CAD), Japan (JPY), Korea (KRW), Mexico (MXN), Norway (NOK), Switzerland (CHF)

Source: Timmer et al. (2015). Note: I use GO/GDP ratios hence currencies play no role.

### Appendix B. Cross-Country Boom-Bust Statistics



Note: Capital misallocation is the cumulative sum over the years 2001 until the year before a downturn. For some countries this exceeded 1 year of negative growth in which case I also included the next year in  $\Delta$  GDP during downturn. As the scatterplot shows, some countries did not experience a clear boom-bust scenario. Excluding these from the results does not change the significance of the correlation coefficient.