



Total factor productivity and the propagation of shocks: Empirical evidence and implications for the business cycle



Eric Mayer^{a,*}, Sebastian R uth^b, Johann Scharler^c

^a Department of Economics, University of W urzburg, Sanderring 2, 97070 W urzburg, Germany

^b Department of Economics, Ghent University, Sint-Pietersplein 5, 9000 Gent, Belgium

^c Department of Economics, University of Innsbruck, Universit tsstrasse 15, A-6020 Innsbruck, Austria

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ABSTRACT

Using a robust sign restrictions approach, we study the response of total factor productivity (TFP) to structural shocks in a VAR framework. We find that TFP increases in response to adverse supply, demand, and wage mark-up shocks. Results for monetary policy shocks are insignificant. Following an adverse technology shock and reductions in government spending, TFP declines. Overall, we conclude that TFP fluctuates endogenously over the business cycle, a feature of the data that is not present in standard DSGE models.

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1. Introduction

How is productivity linked to the business cycle? The standard approach in business cycle models is to view total factor productivity (TFP) as a source of exogenous shocks, which give rise to fluctuations in aggregate output. In fact, in real business cycle theory it holds that exogenous TFP shocks are the main driving force behind business cycles. Although New-Keynesian models typically assign a less prominent role to TFP, these shocks are also considered in this class of models. In this paper, we show empirically that TFP is not only a source of exogenous shocks, but also responds endogenously to changes in the economic environment. In other words, we go beyond the usual interpretation of TFP and study its role as part of the transmission mechanism for macroeconomic shocks more generally.

We apply a robust sign restrictions approach as in Peersman and Straub (2009). We first derive sign restrictions, which are robust to different calibrations, on the basis of the Smets and Wouters (2007) model. Next, we estimate a vector autoregressive (VAR) model and impose the derived restrictions on the impulse responses to identify the shocks. Specifically, we identify an aggregate demand shock, an aggregate supply shock, a wage mark-up shock, monetary policy shock and a technology shock. Importantly, we leave the response of TFP unrestricted, since the Smets and Wouters (2007) model does not offer any predictions with respect to the endogenous response of TFP.

* Corresponding author.

E-mail addresses: eric.mayer@uni-wuerzburg.de, mayeric@gmx.de (E. Mayer).

We find that TFP increases in response to adverse shocks, with the exception of the technology shock, which gives rise to a persistent decline in TFP, while monetary policy shocks generate insignificant TFP dynamics. Although the dynamics depend somewhat on the type of shock, non-technology shocks lead to an endogenous increase in TFP over the medium run, a feature that is missing from the standard New-Keynesian model.

Our results are consistent with the view that firms implement productivity enhancing measures in a counter-cyclical way. For instance, [Philippon \(2006\)](#) argues that corporate governance improves counter-cyclically, which plausibly also raises productivity, and [Berger \(2012\)](#) emphasizes that corporate restructuring also occurs counter-cyclically. The idea that improvements in productivity occur counter-cyclically is also closely related to the debate on whether recessions should generally be viewed as periods during which outdated technologies are eliminated and resources are shifted to more productive uses (see, e.g., [Schumpeter, 1934](#)). This view is controversial and a number of papers emphasize adverse effects of recessions on the allocation of factors. [Caballero and Hammour \(2005\)](#) point out that an improvement of the allocation requires that factors are shifted from less to more productive occupations and although job destruction, which basically makes resources available for better uses, increases during recessions, job creation slows down.¹ However, even if labor is reallocated only with substantial time lags, productivity may increase in the short-run if it is primarily the most productive worker who is retained during recessions ([Berger, 2012](#)).²

The paper is structured as follows. In [Section 2](#) we derive robust sign restrictions, which we will use to identify structural shocks in the empirical analysis discussed in [Section 3](#). [Section 4](#) reports the main results while [Section 5](#) presents additional analysis. [Section 6](#) concludes the paper.

2. Deriving robust sign restrictions

In this section we derive robust sign restrictions based on the [Smets and Wouters \(2007\)](#) model. Using these restrictions, we identify structural shocks in the empirical analysis. We use the [Smets and Wouters \(2007\)](#) model as it is a rather general New-Keynesian model, which currently represents the workhorse model in business cycle theory. Note that the [Smets and Wouters \(2007\)](#) model itself remains tacit with respect to the response of TFP to other shocks since TFP is included only as an exogenous variable, which, by definition, does not respond endogenously.

We consider the model to be common knowledge and refrain from describing the details in terms of equations. Instead, we only explain the origins of the shocks that drive the cycle.

To derive sign restrictions that are robust to different calibrations of the model, we follow the approach advocated in [Peersman and Straub \(2009\)](#). We draw random values for the structural parameters from a uniform distribution and simulate the model. [Table 1](#) summarizes the structural parameters of the model and for each parameter the range of the distribution from which we draw. As a benchmark, the parameter intervals are based on the posterior distribution of structural parameters of the [Smets and Wouters \(2007\)](#) model, although we often extend ranges beyond the 90% credible set. We repeat this procedure 100,000 times.

With respect to the capital bloc of the model, we allow the share of capital in production, α , to vary from 0.16 to 0.4, which includes 0.3, a value commonly used. Investment and capital utilization adjustment cost, φ and ψ , range from 3 to 8 and 0.3 to 1.0, respectively. We set the quarterly depreciation rate to $\delta = 0.025$, and the parameter ϕ_p , which reflects the share of fixed costs in production to one plus 0.5. The parameter intervals for nominal rigidities in product and labor markets are also close to the posterior ranges as in [Smets and Wouters \(2007\)](#). In particular, the Calvo parameter, ζ_p , ranges from 0.2 to 0.9, and the price indexation parameter, ι_p , varies from 0.1 to 0.4. The interval for the Calvo wage parameter, ζ_w , encompasses 0.5 to 0.85, and we draw the wage indexation parameter, ι_w , from 0.35 to 0.8. The Kimball goods market aggregator ranges from 8 to 12. We anchor the coefficients in the Taylor rule generously around the posterior distribution of the [Smets and Wouters \(2007\)](#) model. The inflation coefficient, r_π , ranges from 1.5 to 3.0, the output coefficient, r_y , ranges from 0 to 0.15, interest rate smoothing, ρ , varies from 0.5 to 0.9, and the coefficient that responds to the change in inflation, $r_{\Delta\pi}$, ranges from 0 to 0.3. We set the quarterly gross trend inflation rate, $\bar{\pi}$, to 1.0075 and the discount rate, β , equal to 0.9984. With respect to the utility function, we allow the degree of habit formation, h , to fluctuate from 0.4 to 0.8. The degree of risk aversion varies from $\sigma_c = 1$ to 2.5. The elasticity of labor supply, σ_l , varies from 1 to 3. Finally, we restrict the persistence of all shocks according to the posterior values as reported in [Smets and Wouters \(2007\)](#) and reproduced in [Table 1](#).

2.1. Exogenous shocks

We evaluate the following seven shocks in terms of robust sign restrictions.

- *Risk premium shock*: The risk premium shock drives a wedge between the interest rate set by the central bank and the relevant rate of interest in the consumption and investment Euler equations. A positive shock to the risk premium

¹ See [Barlevy \(2002\)](#), [Barlevy \(2003\)](#), and [Ouyang \(2009\)](#) for alternative views on how recessions may adversely influence the allocation of resources. [Beaudry et al. \(2014\)](#) argue that although past over-accumulations are corrected during recessions, which should improve the allocation, inefficiencies may still emerge due to the increase in uncertainty associated with re-allocations.

² [Jaimovich and Siu \(2012\)](#) show that routine, middle-skill jobs are lost especially during downturns. See [Field \(2003\)](#) for a discussion of labor hoarding and selective firing during the Great Depression.

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