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Jiří Podpiera [*]

Abstract

In this paper we propose an alternative method for deriving the business cycle. We interpret the varying inflationary responses to a constant demand shock in a partial equilibrium model. An above-average inflationary response indicates a boom phase and a below-average response shows an economic slowdown. Our model uses data for prices and household budget shares which are not subject to revisions and are consistent with the inflation measure. Hence, it mitigates the common drawbacks of usually applied techniques, such as real-time data mis-measurement or end-point bias of univariate filters. It follows that the results are altered neither by GDP data revisions, labor share determination and NAIRU estimation and total productivity smoothing, nor by the end-point bias of data filtering. The proposed method is thus preferred to other complementary methods such as GDP series filtering or the production function approach in showing truly the inflation environment. It is applied to the Czech quarterly data during 1994-2003 and compared to other available business cycle estimates for the Czech economy. Comparing our business cycle estimation method with the production function method, used by the Economic Intelligence Unit and the Czech Ministry of Finance, and the Kalman filter, used by the Czech National Bank, we found the highest correlation between our measure and the Economic Intelligence Unit's indicator.

JEL Codes: E31, E32, E37, C30.
Keywords: Business cycle, inflation environment, simultaneous model.

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Nontechnical Summary

In this paper we present an original method for deriving the business cycle. Based on the observed historical synchronization of the real product fluctuations and inflation, we suggest deriving the business cycle using simulated inflation responses. In particular, we interpret the inflation responses to an increase in nominal expenditures that are based on an estimated partial equilibrium model.

Based on our model, which uses price data and household budget shares, a simulated demand shock (an increase in nominal expenditure) would produce either an above-average or below-average acceleration in aggregate price level depending on the phase of the business cycle. In a boom phase, the expected intuitive outcome would be an above-average acceleration in the price level. A below-average price level reaction would be observed in the situation of an economic downturn or recession.

The standard measures of business cycle usually based on output gap evaluation using real time data are known to be imprecise. The implications of uncertainty in their measurement for macroeconomic policy are significant and well documented. Therefore, mitigating the uncertainty in the indicator is a high priority. The widespread application of the business cycle measure makes accurate measurement of it all the more important.

The proposed indicator ought to be more accurate in identifying the business cycle than alternative methods. It eliminates the two major drawbacks of the methods commonly used for filtering GDP series. Unlike the filter-based methods, our method is not affected by end-point bias. In addition, because it uses data on prices and budget shares, which are not subject to revisions, it preserves the relationship between real-time data and price dynamics.

We applied our method to the Czech data during 1994–2003 and performed a comparison within available range of Czech business cycle measures. We compared our measure of the business cycle (IBC) to estimates using the production function of the Czech Ministry of Finance (CMF) and the Economic Intelligence Unit (EIU). Further, we compared the output gap results from the Kalman filter estimation (KF) by the Czech National Bank with the IBC.

We found that all listed measures of the business cycle are mutually highly correlated. The most closely correlated measure of the business cycle with our estimate of IBC is that of the EIU. However, the size of the business cycle varies significantly across methods. The IBC, the EIU and the KF turned out to be equivalent up to certain constant multiple. In contrast, the CMF departed from the common view of all other indicators by crossing the neutral line in 2001.

1. Introduction

The identification of the position of an economy in the business cycle is viewed by many institutions as a key leading indicator of the inflation environment. Central government institutions use the business cycle indicator in formulating strategy on structural budget deficits. The monetary authorities have the business cycle indicator directly incorporated into their policy tool reaction function. Moreover, many institutions, such as the European Commission, plan to base the assessment of the convergence criteria on this indicator (EPC 2001). In addition, the business cycle indicator has proved to be a necessary component of structural VAR models, which are increasingly used in economic policy practice. As Giordani (2001) shows, omitting the business cycle measure from VAR models gives rise to misspecification and causes the price puzzle to appear.[1]

The widespread application of the business cycle measure makes accurate measurement of it all the more important. The implications of uncertainty in its measurement for macroeconomic policy are well documented. Ehermann and Smets (2001), for instance, found a significant impact of the uncertainty in business cycle measurement on actual monetary policy decisions. Therefore, mitigating the uncertainty in the indicator is a high priority.

In policy practice, the business cycle measure used to indicate the inflation environment is obtained by evaluating the *output gap*. The output gap is computed as the percentage difference between trend output and the actual level of production. The gap in production is observed to be well synchronized with price dynamics and thus proves to be timely indicator of price developments.

Two groups of techniques are widely used for extracting output fluctuations: univariate and multivariate. The univariates are statistical methods that use a particular filtration technique to derive de-trended real GDP series. Guarda (2002) provides a survey of univariate techniques. Among the most frequently applied is the Hodrick-Prescott filter (HP), first described in Hodrick and Prescott (1997). The European Commission (EPC Reports 2001), for instance, applies the univariate method as well.

The multivariate techniques for trend product evaluation are based either on a production function or on an extended structural filter (Kalman filter). At the core of the production function approach is the estimation of the non-accelerating inflation rate of unemployment (NAIRU) and smoothed total factor productivity together with the share of labor in production. The resulting smoothed values are used to evaluate the trend product and thus the gap in production. The Kalman filter approach uses part of the structural information about the NAIRU to filter out the gap in real product. The multivariate approach utilizes univariate techniques for smoothing some components of the production function. The multivariate approach is mainly applied by the IMF (De Masi, 1997), the OECD (Giorno et al., 1995), the ECB (Willman, 2002), and the European Commission (EPC Reports, 2001).

[1] The price puzzle denotes the surprising outcome of VAR or structural VAR models of an immediate increase in consumer inflation after a monetary policy tightening and a slowdown in inflation after an easing (Christiano et al. 1998).

In the Czech Republic, the two leading policy makers, i.e., the Czech National Bank (CNB) and the Czech Ministry of Finance (CMF), use different multivariate approaches. The CNB employs a structural Kalman filter (KF) and the CMF uses the production function method (PF). In addition, a leading database of The Economist – the Economic Intelligence Unit (EIU) – publishes its view of the growth of potential product in the Czech Republic based on the PF method.

The business cycle identification is subject to two kinds of uncertainties: data and methodological. The data-specific uncertainty is especially exacerbated in transition economies such as the Czech Republic, where one would expect frequent changes in trend due to structural transformation. Frequent output data revisions and short time series increase the uncertainty of the business cycle measure. The bias in the evaluation of the output gap based on real-time data and revised data is in magnitudes of many percentage points. Orphanides and Norden (2002) showed on U.S. data that output revisions caused misplacement of the output gap by ±4 percentage points on average over 30 years. Especially in combination with the short time series for the Czech Republic, this causes substantial changes in the re-computed output gap with every single additional incoming or revised data point. The size of the reassessment of the KF by the CNB is in the magnitude of ±1 percentage point during 2002–2003.

The methodological source of uncertainty in business cycle identification using multivariate approaches lies in the lower reliability of the last value from the filtered time series. The methods are subject to econometric expertise regarding the setting of the terminal condition in the KF. In the PF the application of univariate techniques for component filtering introduces end-point bias into the business cycle measure.

The documented uncertainty regarding measurement of the business cycle makes policy practice more difficult. Therefore, we propose an alternative method for a business cycle (inflation) indicator that is more consistent with the inflation measure (non-sensitive to data revisions) and free of end-point bias.

Here, we assert that the measure of the phase of business cycle, commonly measured by the output gap, can be equally well based on simulation of the inflationary response to a demand shock. In particular, we develop a directly estimable partial equilibrium model useful for simulation of the demand shock. The model consists of a system of structured supply and demand. Supply is determined by marginal cost production factors and demand is represented by the Almost Ideal Demand System of Deaton and Muellbauer (1980).

Based on our model, which uses price data and household budget shares, a simulated demand shock (an increase in nominal expenditure) would produce either an above-average or below-average acceleration in aggregate price level depending on the phase of the business cycle. In a boom phase, the expected intuitive outcome would be an above-average acceleration in the price level. A below-average price level reaction would be observed in the situation of an economic downturn or recession.

Our method is likely to be more reliable than the multivariate methods based on often-revised output data, as it uses price and budget shares data that are free of revisions. Even if the price data are also measured with a certain bias, the measurement bias is common to both the inflation dynamics and the business cycle measure, since it is based on the same data set. Consequently, the link between the business cycle and inflation conditions is likely to remain unaffected by plausible price data revisions. This contrasts with the different measurement bias in output and inflation, where the relationship between the output gap on real-time data and inflation thus remains ambiguous. In addition, the proposed method provides a more precise indication of the current state, as it is not sensitive to end-point bias or the terminal condition setting.

We test the proposed methodology on data for the Czech economy during the period of economic reform prior to EU accession, i.e., 1994 to 2003. Since the European Commission imposes on all accession countries the production function technique for evaluating the output gap as a basis for convergence program assessment, we perform a comparison of the results of the available methods for the Czech Republic. We compare our results with the outcome of the KF used by the CNB and the PF employed by the CMF and EIU.

The rest of the paper is organized as follows. Section 2 presents the estimable model used for the simulation. Section 3 describes the demand shock simulation procedure. Section 4 gives the results of estimating the model and comments on the parameter estimates. Section 5 compares the results of the computed business cycle indicator with the CNB, CMF and EIU indicators. Section 6 concludes.

2. The Estimable Partial Equilibrium Model

Let us consider a simultaneous partial equilibrium in *n* markets for consumer products.[2] The equilibrium prices and quantities of all products are a result of the interaction between consumers and suppliers. Let us assume that in each market, consumers create demand for a particular product by considering the product's relative price to the *n-1* prices of the other products and real income. Real income is represented by the ratio of nominal income to the aggregated price level of the *n* products.

In order to simplify the analysis we will work with an average consumer instead of the whole distribution of consumers. Following Muellbauer (1975), we assume that consumers have preferences that satisfy the *price independent generalized linearity condition*.[3] Under this condition, the economic behavior of an average consumer is identical to the behavior of every single consumer. In particular, the symmetry and separability restrictions are preserved while aggregating over consumers.[4] In terms of the budget share of an average consumer for good *i* at time *t*, following Deaton and Muellbauer (1980) we write the demand function as:

$$\overline{\omega}_{i,t} = \alpha_i^* + \sum_{j=1}^{n} \gamma_{i,j} \log(p_{i,j}) + \beta_i \log(\tfrac{x_t}{P_t^s}) + \varepsilon_t \qquad (1)$$

[2] The number of markets considered is naturally dependent on the spectrum of consumed products.

[3] For details of a more general form of *PIGLOG* demand $w_i(y,p)=\log yA_i(p)+B_i(p)$ and expenditure functions $y=H(p)^u B(p)$, see Muellbauer (1975) p. 526.

[4] Note that the aggregation over groups of products is easier, since it is solved by introduction of the separability condition into the indirect utility function. For details, see Muellbauer (1975) p. 525.

where $\overline{\omega}_{i,t}$ denotes average budget share, p_j is the price of product *j*, x_t is the average nominal expenditure and P_t^s denotes Stone's price index.[5] $\alpha_k^* = \alpha_k - \beta_i \log\phi$ and $\log P_t^s = \sum_k \overline{\omega}_{k,t} \log p_{k,t}$. $\alpha_i^*, \gamma_{i,j}$, and β_i are unknown parameters.

Having $\beta_i > 0$ would imply that the product is a luxury. On the contrary, if $\beta_i < 0$ we would classify the product as a necessity. The following restrictions have to be satisfied by the definition of the demand system: $\sum_{i=1}^{n} \alpha_{k,i} = 1$, for all *k*, $\sum_{i=1}^{n} \gamma_{i,j} = 0$, $\sum_{i=1}^{n} \beta_i = 0$, $\sum_j \gamma_{i,j} = 0$, and $\gamma_{i,j} = \gamma_{j,i}$. These restrictions represent, respectively, homogeneity of degree zero, Slutzky symmetry, and summing of marginal expenditures to zero. $\varepsilon_{i,t}$ is the white noise component.

As the counterpart, the price of the supplied goods is determined partially by the marginal cost of production and partially by the size of the demand in each market (assuming imperfectly elastic supplies). The prices of inputs (such as wages), the price of intermediate goods and the interest rate represent the marginal costs of production. Besides the standard marginal costs, we included the nominal exchange rate, because in a small open economy the exchange rate plays an important role in price determination. In addition, the price of a particular product is assumed to be derived to some extent from its past value. This is due to the historically observed sluggish price adjustment; see Fuhrer (1997) for more discussion. The formal model of supply for good *i* is given by:

$$\log p_{i,t} = \delta_i \log p_{i,t-1} + \rho_i \overline{\omega}_{i,t} + \psi_i \log PPI_t + \phi_i R_t + \xi_i \log w_t + \theta_i \log ER_t + \upsilon_{i,t} \qquad (2)$$

where $p_{i,t-1}$ represents the one-period lagged price index of product *i*, $\overline{\omega}_{i,t}$ stands for the budget share devoted to the good *i*, PPI_t denotes the producer price index, R_t is the nominal interest rate, $w_{i,t}$ is the index of average wages and ER_t represents the nominal effective exchange rate. $\upsilon_{i,t}$ denotes the error term, which is assumed to be white noise.

Based on the hereby formulated *n* demand and supply system – equations (1) and (2) – one can estimate the parameters and verify their significance. If *n* products encompass all the categories of the consumer price index (CPI), we can derive the CPI (Laspeyres price index) using the data fitted by the model and compare to the actual data on the CPI.

The model asserts attempts to explain movements in the aggregated price level by modeling the evolution of relative prices. Relative prices are determined by marginal cost factors of production and consumers' decisions about budget allocation. The reallocation of consumers' budgets is driven by real income and own-price and cross-price elasticities, which are heterogeneous across product groups. Optimal budget reallocation among the product groups creates various demand pressures across the product groups, which in turn has direct implications for the development of relative prices (provided that the supplies are not perfectly elastic). An increase in expenditure causes either an above-average or below-average acceleration of the aggregate price level. This

[5] Stone's price index approximates the true price index when the price indices are collinear. (For details, see Deaton and Muellbauer, 1980).

means that an increase in nominal expenditure is lowered to a varying extent by an increase in the price level. The size of the aggregate price level increase generated will depend on the phase of business cycle. In periods of boom, the induced price increase will be greater than in a recession.

Therefore, using the estimated model we test the following hypothesis: If an economy is in an economic boom phase, a percentage increase in nominal spending is consistent with a higher induced aggregated price level increase than in a recession phase. This is because in a boom it is easier for prices to accommodate the demand shock than under economic recession. By simulating an increase in nominal spending in each time period, we can derive the equilibrium real spending impulse response. The equilibrium impulse response in the price level can be thought of as an indicator of the inflation environment and hence can be regarded as a business cycle indicator.

3. The Equilibrium Real Expenditure Impulse Response

The system of supplies and demands is non-linear at the aggregated price level. Therefore, the solution for the impulse response function is not directly expressible and we have to use an iterative method. Starting with an initial value for price, we can derive the optimal budget share allocation as follows:

$$W_t^{*'} = B_t^{D*-1} A_t^{D*} \tag{3}$$

where $W_t^{'} = [\overline{\omega}_{1,t}^{'}, \overline{\omega}_{2,t}^{'}, ..., \overline{\omega}_{n,t}^{'}]$ denotes the vector of optimal budget shares allocation at each time *t,* simultaneously on *n* markets. The remaining matrices are given by:

$$B_t^{D*} = \begin{pmatrix} 1+\hat{\beta}_1 \log p_{1,t} & \hat{\beta}_1 \log p_{2,t} & ... & \hat{\beta}_1 \log p_{n,t} \\ \hat{\beta}_2 \log p_{1,t} & 1+\hat{\beta}_2 \log p_{2,t} & ... & \hat{\beta}_2 \log p_{n,t} \\ ... & ... & ... & ... \\ \hat{\beta}_n \log p_{1,t} & \hat{\beta}_n \log p_{2,t} & ... & 1+\hat{\beta}_n \log p_{n,t} \end{pmatrix}$$

and

$$A_t^{D*} = \begin{pmatrix} \hat{\alpha}_1^* + \sum_{j=1}^n \hat{\gamma}_{1,j} \log p_{j,t} + \hat{\beta}_1 \log x^s{}_t \\ \hat{\alpha}_2^* + \sum_{j=1}^n \hat{\gamma}_{2,j} \log p_{j,t} + \hat{\beta}_2 \log x^s{}_t \\ ... \\ \hat{\alpha}_n^* + \sum_{j=1}^n \hat{\gamma}_{n,j} \log p_{j,t} + \hat{\beta}_n \log x^s{}_t \end{pmatrix}$$

where $x^s{}_t$ denotes the level of expenditure after a demand shock (an increase in nominal expenditure). Using the optimal budget shares derived in (3) as the optimal values we can evaluate the optimal price vector $\prod_t^{*'}$ from the system of supply functions. The supply system written in matrix form is represented by the following relation:

$$\prod_t^{*'} = I_{nxn} A_t^{S*} \tag{4}$$

where $\Pi_t^{*'} = [\log p_{1,t}^*, \log p_{2,t}^*, ..., \log p_{n,t}^*]$ is the optimal price vector. I_{nxn} denotes the diagonal matrix, and the matrix of supply functions is given by:

$$A_t^{S*} = \begin{pmatrix} \hat{\delta}_1 \log p_{1,t-1} + \hat{\rho}_1 \overline{\omega}_{1,t} + \hat{\psi}_1 \log PPI_t + \hat{\phi}_1 R_t + \hat{\xi}_1 \log w_t + \hat{\theta}_1 \log ER_t \\ \hat{\delta}_2 \log p_{2,t-1} + \hat{\rho}_2 \overline{\omega}_{2,t} + \hat{\psi}_2 \log PPI_t + \hat{\phi}_2 R_t + \hat{\xi}_2 \log w_t + \hat{\theta}_2 \log ER_t \\ ... \\ \hat{\delta}_n \log p_{n,t-1} + \hat{\rho}_n \overline{\omega}_{n,t} + \hat{\psi}_n \log PPI_t + \hat{\phi}_n R_t + \hat{\xi}_n \log w_t + \hat{\theta}_n \log ER_t \end{pmatrix}$$

The iterative procedure uses the retrieved optimal values of the price indices as the initial values for the next iteration starting in equation (3). By comparing the retrieved optimal values for the price vector from equation (4) to the initial values entering the beginning of the iteration in equation (3) we assess the convergence in optimal prices. When the retrieved optimal prices do not change after the *j-th* iteration, we have found the vectors of the equilibrium prices and budget shares. Using the price vector we derive the CPI and evaluate the dynamics in real expenditure, which are defined as follows:

$$\frac{x_t^{r,s}}{x_t^r} = \frac{x_t^s}{x_t} \frac{CPI_t}{CPI_t^s} \tag{5}$$

where $x_t^{r,s}$ is the resulting level of real expenditure after an increase in nominal expenditure x_t^s, x_t^r is real expenditure prior to the increase in spending, CPI^s_t is the consumer price index after the nominal rise in expenditure, and CPI_t is the consumer price index corresponding to the original level of spending x_t.

From relation (5) it follows that the impulse of a nominal spending increase might be less than equally translated into an increase in real expenditure. Prices respond differently to a nominal increase in spending in a recession as compared to a boom. We interpret the difference in the size of the price increase as an indicator of the business cycle. This indicator is the most consistent of all the complementary indicators with the idea of measurement of the inflation environment.

4. Data Issues

The empirical analysis extends over the period of 1994 to 2003. We divided the sample into two sub-samples. The first sub-sample – covering 1994 to 2001 – was used for estimation of the model's parameters, whereas the remaining two-year period of 2002–2003 was reserved for out-of-sample prediction.

We used household budget surveys data and price indices in the first stratum of the consumer price index (CPI) at quarterly frequency. These are available from the Czech Statistical Office (CSO).

The choice of the number of product groups analyzed was determined by the relatively short available sample of eight years of quarterly data. An increase of one in the number of analyzed products increases the demand for the estimated parameters in the system of demands by *2x(n+1)*, while increasing the total degrees of freedom by a constant of 32 only (4x8). Therefore, we focused on the limited number of product groups that constitute the first stratum of the CPI.

The price indices and average household budget shares in the structure of the first stratum of the CPI underwent a methodological change in 1999, when the CSO adopted an amendment to its product classification methodology. Hence, some products were transferred across product groups, introducing a discontinuity into the data series in our sample.

Exact computation of the price indices in the structure prior to 1999 was not feasible due to a lack of detailed background data. Although the major movements took place within the lower strata of the CPI, some products were moved between product groups in the first stratum (see CSO, 1999). Therefore, in order to preserve maximum data consistency, we made the following adjustment in the structure of the product groups. We identified the groups of products among which most of the transfers had taken place and moved the majority of the particular items back to their original product group placement as defined in the old methodology. Where the majority of the underlying subtle data were not available, we created a new, larger, product group by merging two groups. In this way, we defined a slightly modified set of 9 product groups as compared to the standard 12 in the first CPI stratum.[6] The groups of products we consider to have satisfactory continuity across the methodology change are summarized in Table 1.

Table 1: Overview of product group definitions and their relationship to the CPI basket

Category	Description (placement in CPI)	Consistency
Food	Food (01)	Full
Beverages	Alcoholic (02), non-alcoholic (01) beverages and tobacco (02)	Satisfactory
Clothing	Clothing (03) and footwear (03)	Full
Heating	Heating (04) and lighting (04)	Full
Rent	Rent for dwelling (04) and household equipment (05)	Satisfactory
Personal	Personal (12) and medical care (06)	Full
Culture	Culture and entertainment (09), education (10), recreation (11)	Satisfactory
Transport	Transport (07) and communication (08)	Satisfactory
Miscellaneous	Miscellaneous goods and services (12)	Full

Note: Scale of the consistency measure as published by the Czech Statistical Office: full, satisfactory, and poor.

The data for wage indices as well as the producer price index (PPI), the nominal effective exchange rate (NEER) and the 3M Pribor were obtained from the Czech National Bank (CNB) database. The business cycle measure using the production function approach was obtained from the Czech Ministry of Finance website and the database of the Economic Intelligence Unit. The Kalman Filter estimate of the gap in production was provided by the CNB.

[6] The adjustments mainly concern the following items: by merging *Non-alcoholic* and *Alcoholic beverages* we significantly improve the comparability, as the inconsistency was caused almost exclusively by non-alcoholic beer, which had been transferred from *Food* to *Beverages*. In the case of *Rent for dwelling* and *Household equipment*, merging these two groups yields a 50% improvement in the comparability from the worst classification. Likewise, merging *Culture*, *Entertainment* and *Education* earns a comparability improvement of 30%, although this remains the least consistent group of products.

Data for the most plausible future development of the exogenous variables, i.e., nominal expenditure, 3M Pribor, NEER, wages and PPI, in 2002–2003 were taken from the CSO, the CNB and the Consensus Forecast Eastern Europe.

5. Results of Estimating the Equilibrium Model

The parameters of the equilibrium system of nine product groups were estimated using 3SLS.[7] The results of the parameter estimates are presented in Table 2. The columns of Table 2 represent the estimated equations (dependent variables). The rows contain the explanatory variables: in the upper region for demand and at the bottom for supply. T-ratios are given in parentheses and statistical significance is conventionally labeled using asterisks: ***, ** and * respectively for the 1%, 5% and 10% significance levels.

The demands for the majority of goods were estimated with a high coefficient of determination. The average R^2 over all demand functions equals 0.97. Such a good model fit could be due to small-sample properties, with the model fitting the data because there is not much variation in it. Therefore, we complement the goodness of fit with an additional diagnostic about the model's performance. We derive the ratio of significant coefficients to total number of coefficients. In the case of the demand system (see the upper region of Table 2), this ratio equals 0.39. By comparison with the result of 0.33 obtained by Deaton and Muellbauer (1980) using a similar data set for the UK, our model appears to be performing relatively well. Similarly, in the case of the supply system (see the lower region of Table 2), the ratio of significant coefficients to all coefficients is 0.59. Together with almost perfect fit measured by coefficient of determination (0.98 on average over the supply equations) this makes the whole system reasonably well identified.

The sign of the estimated elasticity of real income (see coefficients β_i in Table 2) determines whether a good is a necessity or a luxury. According to their estimated negative and significant elasticity, the product groups *Food*, *Beverages*, *Culture* and *Transportation* appear to be necessities. Our finding supports the intuition about the demand for these product groups in the Czech Republic during our sample period, which is characterized by ongoing economic transformation. The relative budget share for transportation, entertainment, recreation and cultural events would be expected to have strengthened as the borders opened up for Czech citizens. Therefore, despite the decrease in real income caused by the increase in the aggregate price level, the demand for the listed product groups increases relative to other products. In contrast, the product groups *Clothing* and *Personal care* are identified as luxuries. Finally, *Rent*, *Heating* and *Miscellaneous* could not be unambiguously classified in either category, due to their elasticities being either very low or zero with respect to the statistical significance.

[7] For further details on the method, see Greene (2003) p. 405.

Table 2: Demand and Supply by Product Groups

Product:	Food	Beverages	Clothing	Heating	Rents	Personal	Culture	Transport	Miscellaneous
Demand:									
Food	0.2 (1.4)	-0.07* (-1.4)	0.17*** (2.2)	-0.06 (-1.2)	-0.02 (-0.1)	0.16*** (2.1)	-0.73*** (-3.6)	-0.06 (-0.3)	0.4 (0.5)
Beverages	-0.1 (-0.9)	0.08 (1.0)	-0.3*** (-3.3)	0.25*** (2.8)	-0.14 (-0.5)	0.3*** (3.2)	-0.3 (-1.3)	0.7*** (2.9)	0.23 (0.3)
Clothing	0.05 (0.2)	-0.09* (-1.4)	0.08 (0.8)	0.01 (0.05)	-0.16 (-0.6)	0.02 (0.3)	-0.32* (-1.4)	-0.07 (-0.3)	-1.7 (-1.1)
Heating	-0.1 (-1.2)	-0.04* (-1.6)	0.02 (0.3)	0.11* (1.7)	-0.28* (-1.5)	0.07 (0.1)	-0.2** (-1.9)	-0.08 (-0.8)	0.59 (1.1)
Rents	-0.06 (-0.2)	0.1 (0.99)	0.03 (0.2)	-0.14 (-0.95)	0.55 (0.9)	-0.09 (-0.6)	-0.04 (-0.12)	-0.03 (-0.1)	-0.03 (-0.1)
Personal	0.4*** (2.3)	0.16*** (2.8)	-0.38*** (-2.4)	0.52*** (4.5)	0.59*** (2.1)	-0.13* (-1.5)	0.47*** (2.2)	0.17 (0.8)	-1.3 (-1.1)
Culture	0.12 (0.5)	0.01 (0.01)	0.21* (1.5)	-0.28*** (-2.9)	0.25 (0.13)	-0.33*** (-2.7)	1.5 (0.3)	-1.1*** (-3.4)	-1.36 (-0.9)
Transport	-0.1 (-1.1)	-0.07* (-1.5)	-0.01 (-0.2)	-0.05 (-1.1)	-0.16 (-0.9)	-0.03 (-0.5)	-0.14 (-0.8)	0.38* (1.7)	-0.48 (-0.8)
Miscellaneous	-0.07*** (-2.1)	-0.01 (-0.5)	-0.04** (-1.9)	-0.03*** (-2.1)	-0.09*** (-2.3)	0.01 (0.3)	-0.03 (-0.6)	0.15*** (2.8)	0.95*** (2.1)
Income	-0.12*** (-3.9)	-0.03*** (-3.3)	0.19*** (3.5)	0.03 (0.7)	0.09 (0.9)	0.08*** (3.5)	-0.17*** (-4.5)	-0.1*** (-2.7)	-0.04 (-0.2)
Supply:									
$p_{i,t-1}$	0.32*** (2.6)	0.68*** (5.8)	0.93*** (5.6)	0.67*** (4.6)	0.89*** (9.4)	0.81*** (13.9)	0.65*** (5.7)	0.69*** (8.2)	0.27*** (2.4)
Budget share	0.98*** (4.9)	1.8*** (2.7)	0.1*** (6.6)	1.3** (1.8)	-0.89 (-0.7)	-0.3 (-0.4)	-0.1 (-0.5)	0.25*** (2.3)	1.5*** (2.4)
Wage	0.14 (1.4)	0.05 (0.9)	-0.01 (-0.9)	0.08 (0.4)	0.5*** (2.3)	0.004 (0.4)	0.27*** (2.4)	-0.01 (-0.2)	2.01*** (4.16)
Interest rate	0.01 (1.1)	0.05* (1.5)	0.07*** (5.9)	0.01 (0.12)	-0.02 (-0.4)	0.04*** (3.6)	0.01 (0.3)	-0.1 (-0.8)	0.16 (0.8)
Producer prices	0.66*** (3.3)	0.31*** (2.4)	0.06** (1.9)	0.64*** (2.3)	-0.85 (-0.8)	0.17*** (2.8)	-0.2 (-0.9)	0.51*** (4.8)	-3.1 (-0.5)
Exchange rate	-0.04 (-0.69)	-0.09** (-1.9)	0.01 (0.4)	-0.45*** (-2.3)	-0.21*** (-2.1)	0.02 (0.9)	-0.1*** (-2.1)	-0.2*** (-3.7)	-0.1 (-0.3)
$\sum_j \hat{\gamma}_{i,j}$	0.19	0.06	-0.3	0.31	0.53	-0.02	0.21	0.15	-2.1
RMSE	0.4/0.004	0.15/0.005	0.22/0.001	0.14/0.0015	0.43/0.007	0.24/0.002	0.57/0.003	0.61/0.005	1.7/0.002
D.W.	1.9/1.5	2.1/1.8	2.3/1.9	2.36/2.2	2.6/2.5	1.75/1.2	2.2/2.3	1.6/2.28	1.82/2.6

Note: t-statistics in parenthesis. Significance level is conventionally denoted by asterisks: *** 1%, ** 5%, and * 10%. Quarterly dummy variables included into demand regressions.

The sum of the elasticities of real income (i.e., coefficients β_i) is equal to zero, $\sum_{i=1}^{n} \hat{\beta}_i = -0.07$. The zero-sum of the marginal expenditures confirms that the additional increase in real income causes a reallocation of the budget shares without any remainder. The restrictions on cross and own price elasticities $\gamma_{i,j}$ are presented in row $\sum_j \hat{\gamma}_{i,j}$ in Table 2. The values are in the majority of cases close to zero as implied by the model.

As follows from the lower region of Table 2, marginal cost factors proved to be important determinants of the supply system. Nominal wages (coefficients ξ_i), the nominal effective exchange rate (coefficient θ_i), the nominal interest rate (coefficient φ_i) and producer prices (coefficient ψ_i) are statistically significant determinants of the price setting. A nominal exchange rate appreciation (an increase in the variable *ER*) tends to decrease prices, which is in line with economic intuition. Similarly, an increase in the nominal interest rate, nominal wages and producer prices increases the upward pressure on prices.

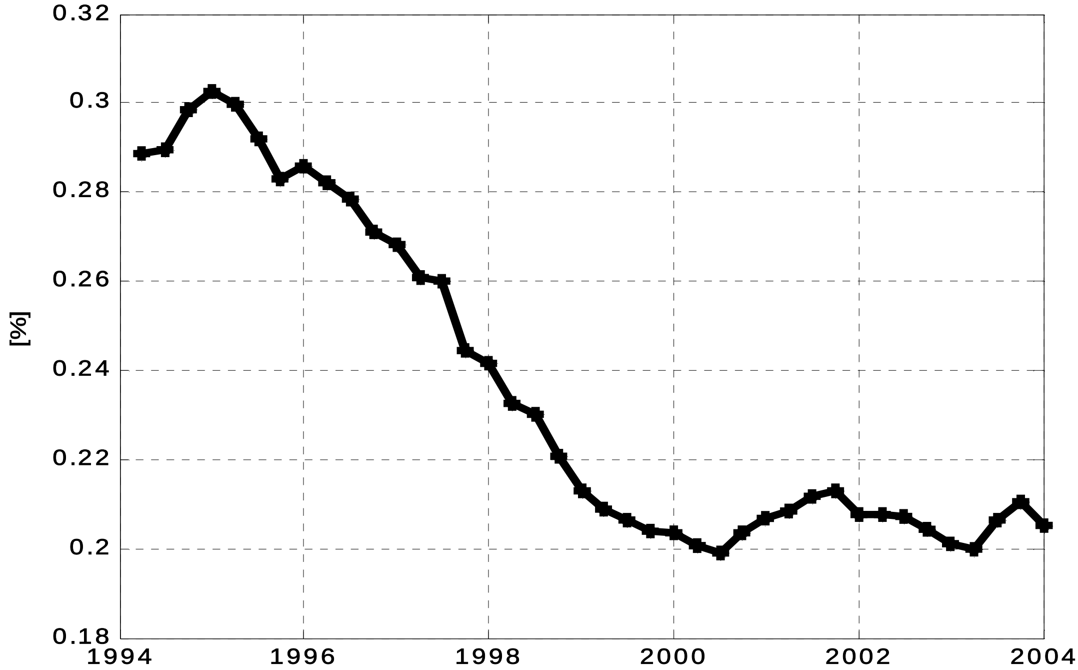
Most crucially, we found that the supplies do not exhibit perfect elasticity. We estimated significant coefficients ρ_i in six out of the nine supply functions, which testifies to imperfect elasticity of the majority of the supplies. The least elastic supply is that for *Beverages,* where a one percentage point change in budget share causes an increase in price of 1.3 p.p. Similarly, *Heating* with elasticity 1.3 and *Miscellaneous* with elasticity 1.5 belong to the group of low elasticity of supply. On the other hand, *Clothing* and *Culture* represent highly elastic supplies. A one percentage point increase in budget share causes a 0.1 p.p. increase in price in the case of *Clothing* and a zero increase in the case of *Culture* (perfectly elastic supply; the t-test shows statistical insignificance). The estimated elasticity for *Food* equals 0.98 and that for *Transport* only 0.25, which suggests that both supplies are rather inelastic.

6. The Business Cycle Identification

The identification of the business cycle in this paper builds on the historically well documented synchronization of de-trended real domestic product and the dynamics of prices in the business cycle. It follows that we can identify the business cycle either from price data or from output data. This explains the parallel in the identification of the business cycle by our measure as compared to alternative approaches such as the Kalman filter (KF) or the production function (PF).

We present an identification of the business cycle which is based on simulation of the CPI inflation response to a demand shock in an estimated partial equilibrium model. In particular, we investigate how the inflationary response to a 10 percent increase in nominal expenditure varies over the business cycle. Our presumption is that an increase in inflation will likely take place in any phase of the business cycle, as the supplies are inelastic, but that in a boom this tendency will be stronger than in a recession. We simulate a ten percentage point increase in nominal spending because this corresponds to the average historical increases in nominal expenditure in the Czech Republic during our sample period. We interpret the inflationary response to the increase in nominal expenditure as an indicator of position in the business cycle (IBC). The inflationary response to a 10 percentage point increase in nominal expenditure is plotted in Figure 1.

Figure 1: Implied inflation by 10% increase in nominal expenditures



As we can see from Figure 1, the inflationary response to an increase in nominal spending varies over time. We can clearly see the switch towards a lower inflation environment during the period of economic slowdown in 1996–1999. During this period, real GDP growth barely exceeded zero. This period was followed by resumed growth, revealed in Figure 1 by slightly rising inflationary pressures during 2000–2001. For the period of 2002–2003, we predicted lower inflationary pressures in 2002 and a slightly strengthened inflationary environment during 2003. The prediction for 2003 shows signs of an upcoming economic expansion.

In order to relate our inflationary business cycle (IBC) results to the results of other commonly used techniques, we had to distinguish the boom phase from the economic downturn. Let us assume that the Czech economic boom peaked in 1995 and that the recession troughed in 2000. The midpoint of the response interval between the bottom of the recession and the peak of the boom determines the turning point; here it is 0.25 percentage points.

We compare the results across the methods applied to the Czech data. We consider the filtering of real GDP using the Kalman filter (KF) as applied by the Czech National Bank, the production function approach (PF) as applied by the Czech Ministry of Finance and The Economist, and the inflation response measure (IBC) derived in this paper. We normalize the different business cycle indicators by their respective standard deviations. In this way, we account for the different volatility of the differently derived measures. In Figure 2 we plot the four indicators of the business cycle.

Figure 2: A comparison of alternative business cycle measures

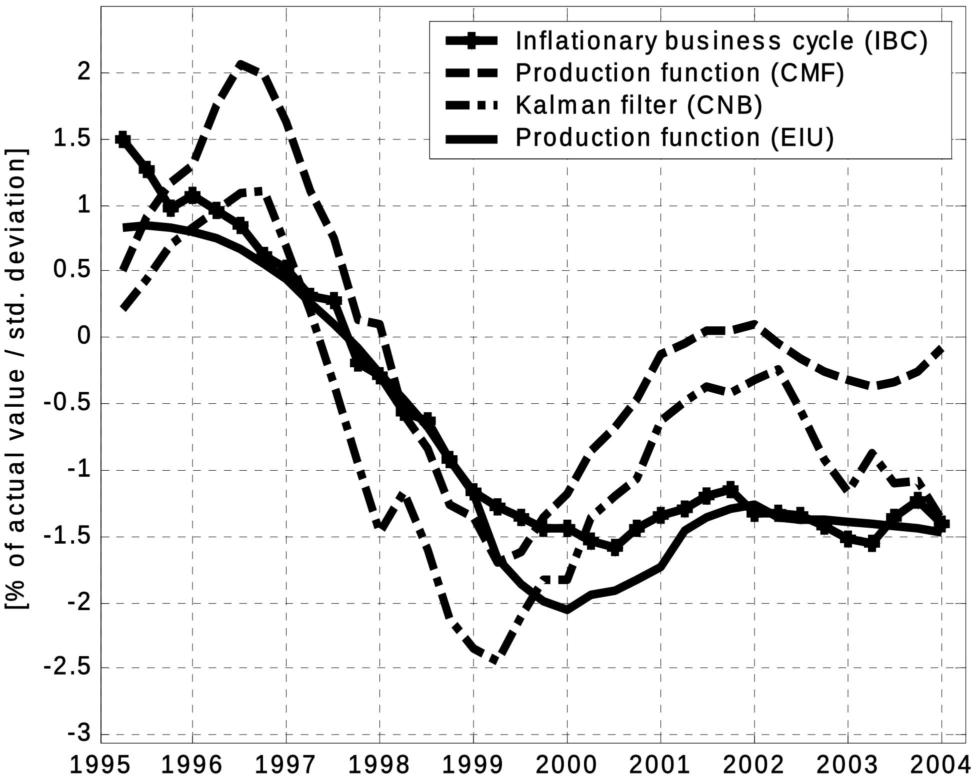


Figure 2 shows the following business cycle indicators: the inflationary business cycle (IBC), the CMF and EIU's production function-based business cycle, and the CNB's Kalman filter approach. Because the EIU only publishes growth rates of potential product and real GDP, we anchored the output gap at zero in the second half of 1997. This corresponds to the view of all the measures.

We can assess the relationships between the various derivations of the business cycle measures depicted in Figure 2 on the basis of the type of data and the methodology used. First, the accuracy of the business cycle measure is determined by the data employed (the degree of measurement bias in real-time data). The data for GDP are not measured with the same type of error as prices. This feature causes potential inconsistencies between de-trended real-time GDP and the CPI dynamics. Second, the precision of the current-period business cycle identification is influenced by the method used: filtering methods involve end-point or terminal condition bias.

In both the KF and PF methods, the GDP series are the main component. The GDP series are affected by a measurement error resulting from multiple data revisions. With each single data revision or additional available data point the business cycle indicator is recomputed. Consequently, the real-time data provides a relatively uncertain measure of the stance in the business cycle (inflation environment). From the evidence of the Czech business cycle computed using the KF on both the real-time data and the revised data we can see the size of the plausible reconsideration of the business cycle stance for the Czech economy. We found that the data revisions quarter on quarter caused a difference between the real-time and the revised data business cycles of one percentage point on average over the period of 2002–2003. (In one extreme case, the revision caused a reassessment of the business cycle from -2.5% to zero in the 2nd to 3rd quarter of 2002). In effect, when we combine the GDP data revisions with the commonly used method of trend filtering, the business cycle indicator using the KF or PF can provide a misleading assessment of the current position in the business cycle.

The method proposed in this paper is based on indicators that are consistent with the inflation measures. Therefore, even if we know that prices are measured with a bias, we still preserve the consistency between the business cycle derived from the price data and CPI inflation. This, coupled with the fact that the price data are not subject to revisions, helps in formulating a more robust story about the inflation conditions. In addition, we believe that our indicator may be more accurate in assessing the current position in the business cycle, as it is not affected by end-point bias.

A disadvantage of the proposed method is its reliance on an average consumer, which to some extent might misdate the turning point of the business cycle.[8] The demand shocks during the business cycle are unequally distributed across consumers as distinguished by level of income. Hence, the estimated parameters of the model for an average consumer's budget shares might not reflect the heterogeneity of shocks in income. This feature can be dealt with by introducing heterogeneity in consumers, i.e., income heterogeneity in the demand functions. Such an extension of the model is, however, left for further research at this point.

Despite the different data and methodology used, the business cycles identified using the different methods are highly correlated. Table 3 reviews the correlation matrix.

Table 3: Correlation

	IBC	**CMF**	**CNB**	**EIU**
IBC	1.0000	0.7863	0.7451	0.9770
CMF	0.7863	1.0000	0.9569	0.8217
CNB	0.7451	0.9569	1.0000	0.7577
EIU	0.9770	0.8217	0.7577	1.0000

Note: IBC – Inflationary Business Cycle, CMF – Czech Ministry of Finance (PF method), CNB – Czech National Bank (KF approach), EIU – Economic Intelligence Unit (PF method).

As we can see in Table 3, the best correlated business cycle measures are the IBC and the EIU, exhibiting a correlation of 0.98. Interestingly, the measures based on the same method, i.e., the EIU and CMF, using the production function, have a correlation of only 0.82. This finding testifies to the crucial importance of expert judgement when applying the production function approach. At the same time the CMF correlates very well with the CNB (0.96). In the light of the correlation of the alternative methods with the IBC, we can confirm the high credibility of the EIU computation of the business cycle. However, due to the high correlation of the IBC with the other measures, the direction of the change in the business cycle is relatively well explained by all the methods.

[8] I thank Randall K. Filer for pointing out this feature of the model.

More crucially, besides the direction of the change in the business cycle, there is the question of analyzing the indicated variety of sizes in the business slowdown or upswing. In this respect, a higher degree of uncertainty prevails. Figure 2 shows that different methods lead to different magnitudes of the business cycle. This feature complicates policy implementation, as one is not sure of the level of the recession or boom. Some measures appear to be more volatile than others. But as the measures normalized by their respective standard errors suggest, each measure can be consistently interpreted independently of the others. The only requirement is that the zero line crossing all measures should be observed at the same moment. From this point of view, the IBC tends to confirm the size of the EIU business cycle and is not in contradiction with the CNB measure. On contrary, the IBC does not confirm the positive output gap in 2001 suggested by the CMF. We could speculate that the discrepancy in the last periods of the CMF and CNB estimations would be subject to reconsideration when revised or additional data points become available.

7. Concluding Remarks

Our analysis, which is focused on the precision of the business cycle identification, is motivated by the widespread application of the business cycle measure in policy-oriented decisions. The business cycle measure (the output gap) plays a key role in the European Commission's assessment of the real convergence of the new EU accession countries, as well as in governmental strategy regarding the structural budget deficit, and is a leading indicator for monetary policy setting.

Our analysis tries to shed light on the business cycle and inflation environment identification. In doing so, we estimate a partial equilibrium model useful for simulating demand shocks. Using the identified model, we simulate the aggregate price level response to an increase in nominal expenditure. The inflationary responses contour the business cycle. An above average inflationary response identifies a boom phase, whereas a below-average response points to an economic slowdown.

Our method is likely to be more accurate in identifying the business cycle than the alternative methods. This is due to the elimination of the two major drawbacks of the methods commonly used filtering GDP series. Unlike the filter-based methods, it is not affected by end-point bias. In addition, because it uses data on prices and budget shares, which are not subject to revisions, it does not defocus the relationship between real-time data and price dynamics like the standard methods do.

We applied the proposed method to the Czech data during 1994–2003. In order to discriminate between the available range of Czech business cycle measures, we compared our measure of the business cycle (IBC) with the available estimates for the Czech Republic, namely, the production-function based measure as used by the Czech Ministry of Finance (CMF) and the Economic Intelligence Unit (EIU), and the output gap using Kalman filter estimation as performed by the Czech National Bank (CNB). We conclude that the most closely correlated measure of the business cycle with our estimate is that of the EIU. The correlation coefficient equals 0.98.

In particular, we found that the EIU business cycle performs better in detecting the inflation environment as compared to the other methods. Based on the IBC we were able discriminate between methods that use the same methodology (production function) and probably a similar data set, yet return different results. The CMF indicator exhibits a much lower correlation with our indicator (0.78) as compared to the EIU measure. Also, a lower correlation was found between our indicator and the CNB's Kalman filter estimate (0.75).

Our framework does not, however, provide an exact discrimination mechanism to decide on the correct level of the business cycle. This is because each indicator exhibits a different volatility, as does our indicator. Thus, each indicator should be interpreted in terms of its amplitudes. However, the neutral line should be crossed at the same moment by all measures, in which case they are equivalent up to a certain scalar multiple. The CMF's indicator deviates from this behavior in 2001. We anticipate that the recent estimates of this indicator will be revised when new data become available.

The importance of our finding for policy decisions is in the discrimination between the available estimates of the business cycle indicators. This importance is heightened in the situation where the same methodology applied to similar or identical data set delivers a different picture of the stance in the business cycle. This reveals the high importance of econometric expertise and underlines exacerbates the uncertainty of such a measure. We believe that our method can provide an insight into the business cycle which could prove helpful in assessing the inflation environment.

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