Forecasts with production expectations integrated into a macroeconomic model

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1 Introduction

Empirical studies have shown that survey production expectations for the manufacturing industry, which are published for most OECD countries, are significant predictors of manufacturing production (Dasgupta and Lahiri [1993], Madsen [1993] and Rahiala and Terasvirta [1993]). The possibility that the information contained in macroeconomic models may improve the forecasts of production from survey production expectations, however, has been disregarded in empirical studies.

In this paper I test whether forecasts of manufacturing production from survey production expectations can be improved by using the information contained in a simple reduced form macroeconomic model. The macroeconomic model is derived from the supply side augmented IS-LM framework assuming imperfect competition in the goods market (section 2). In section 3 the model defines equilibrium production and establishes a cointegration equation. The corresponding error-correction model is then augmented with survey production expectations and forms the forecast equation, which is estimated for 14 OECD countries over the period 1969.1Q to 1994.4Q. Section 4 compares the predictive performance of the model with the predictive performance of a univariate model augmented with production expectations.

2 The Model

This section outlines the reduced form macroeconomic model that is used to form the cointegration regressions and the error-correction models. The model is a reduced form aggregate supply and aggregate demand model, where aggregate supply is derived under the assumption of imperfect competition. The supply side is derived first.

Supply of goods is derived from the assumption of profit maximizing behaviour. The first order condition for profit maximization is given by $W/P = \psi^{-1}MP_L$, where W is hourly wage rate, P is prices, ψ is the price markup over marginal cost and MP_L is the marginal productivity of labour, which is a function of capital stock, technology and labour[1]. Hence, the supply of goods is given by:

$$Y^s = Y^s\left(\underset{-}{\psi}, \underset{+}{\theta}, \underset{-}{W/P}\right), \tag{1}$$

where θ is a productivity parameter which embodies technological advances. The price markup over marginal cost is assumed to be a negative function of real credit and a positive function of price competitiveness vis-a-vis the outside world. A reduction in the access to credit facilities may hamper the firms' ability to produce (Blinder [1987]), which will increase the markup, as firms move down their marginal cost schedule. Furthermore, a shortage of credit may force some firms out of business, which will decrease the elasticity of demand facing the remaining firms. Markup depends positively function of price competitiveness, as an exchange rate appreciation of the domestic currency forces domestic producers to lower their markup to defend their competitive position vis-a-vis the outside world (Fitoussi and Phelps [1988] and Layard and Nickell [1986]). Hence, the domestic producers' production increases.

Thus, equation (1) can be written as:

$$Y^s = Y^s\left(\underset{+}{CR/P}, \underset{-}{E\cdot P^*/P}, \underset{-}{W/P}, \underset{+}{\theta}\right), \tag{2}$$

where CR is credit to the private sector, E is the exchange rate, measured as domestic currency per unit of foreign currency, and P^* is foreign prices.

The demand for goods is determined by the open economy reduced form IS-LM model:

$$Y^d = Y^d\left(\underset{+}{G/P}, \underset{+}{M/P}, \underset{+}{Y^*}, \underset{+}{E\cdot P^*/P}, \underset{+}{A/P}\right), \tag{3}$$

[1] The profit maximization problem is given by:

$$\max_L \pi = P\cdot Y - W\cdot L,$$

where π is profit, L is labour and Y is production. Under the assumption that firms take wages as given but have market power in the goods market, the first order condition for profit maximization is:

$$P\cdot\delta Y/\delta L + Y\cdot\delta P/\delta Y\cdot\delta Y/\delta L - W = 0,$$

or

$$MP_L\cdot P[1+\eta^{-1}] = W, \quad \text{or} \quad MP_L = \psi^{-1}W/P,$$

where η is the numerical value of the elasticity of demand as perceived by the firms and $\psi = [1+\eta^{-1}]$.

where G is nominal government spending, M is nominal monetary stock, Y^* is foreign income and A is nominal financial wealth.

Solving equations (2) and (3) for prices yields the equilibrium income for which the goods and labour markets are simultaneously in equilibrium:

$$Y = Y\left(\underset{-}{W}, \underset{+}{A}, \underset{+}{Y^*}, \underset{+}{G}, \underset{?}{E \cdot P^*}, \underset{+}{M}, \underset{+}{CR}, \underset{+}{\theta}\right). \tag{4}$$

The sign of price competitiveness is ambiguous and depends on whether the markup or the demand side effect dominates. Note that the technology parameter, θ, certifies that income is increasing in the long run along with technological advances. By contrast the demand side variables tend to move on business cycle frequencies.

3 Empirical estimates

In this section equation (4) is first estimated as a cointegration relationship because the variables contained in the equation are integrated of order one. The corresponding error-correction model is then estimated with survey production expectations embedded in the model(2). This method is the two-step procedure suggested by Engle and Granger [1987].

3.1 Stochastic specification

The cointegration equation of equilibrium income given by equation (4) is stochastically specified as:

$$\begin{aligned} y_t &= \alpha_0 + \alpha_1 w_t + \alpha_2 a_t + \alpha_3 y_t^* + \alpha_4 (p^* + e)_t + \alpha_5 m_t \\ &\quad + \alpha_6 cr_t + \alpha_7 \log \theta_t + SD\gamma + TSD\lambda + \varepsilon_t, \end{aligned} \tag{5}$$

where lower-case letters are the logs of capital letters. SD is a vector of seasonal dummies, TSD is a vector of seasonal dummies multiplied by time to allow for changing seasonality over time, α_i, γ and λ is

(2) Augmented Dickey-Fuller (ADF) tests for order of integration were performed for all variables in logs, except production expectations, which were not measured in logs as they can take negative values. A time trend, seasonal dummies and a lagged dependent variable were included as regressors in the ADF tests. At the 5-percent level, all variables in equation (4) are integrated of order one, except three, which are stationary. Since the dependent variable is integrated of order one for all countries, equation (4) can be estimated in log levels. Survey production expectations were stationary for all countries except for Austria, Denmark, France, Ireland, Italy, the Netherlands and Sweden for which they were integrated of order one.

the coefficients vector and ε is a zero-mean, finite-variance disturbance term. Equation (5) is estimated using OLS.

To forecast changes in production the following error-correction model augmented with survey production expectations is estimated:

$$\begin{aligned} \Delta y_t &= \beta_0 + \beta_1 PE_{t-1} + \beta_2 \Delta y_{t-1} + \beta_3 \Delta y_{t-2} + \beta_4 \Delta X_{t-1} \\ &\quad + \beta_5 \Delta X_{t-2} + \beta_6 \varepsilon_{t-1} + SD\phi + TSD\kappa + u_t, \end{aligned} \qquad (6)$$

where PE_{t-1} is production expectations formed in period $t-1$, X is the vector of the explanatory variables used in equation (5), ε_{t-1} is the lagged residual from the estimate of equation (5), β_i, ϕ and κ are coefficients, and u is a serial uncorrelated and normally distributed disturbance term. The PE variable is measured in first differences in the cases where it is integrated of order one. Equation (6) is not a usual error-correction model, because contemporaneous values of the ΔX-variables are excluded from the equation, since it is a forecast equation. Insignificant variables are deleted using the general-to-specific approach, with the 5-percent bench-mark significance level.

3.2 The data

Equations (5) and (6) are estimated for 14 OECD countries over the period from 1969.1Q to 1994.4Q with data from OECD's *Main Economic Indicators*. Only countries where survey production expectations data are available over this period are included in the sample. Income is measured by manufacturing production, since survey production expectations are only conducted for the manufacturing industries, and since quarterly GDP is not available over the whole period for many of the countries. Manufacturing production is an adequate proxy for income, since it is used to measure economic activity in OECD's leading indicator system (OECD [1987]). Money is measured by M1; wage by the hourly wage rate in manufacturing; credit by lending to the private sector; financial wealth by an index of share prices; and the productivity parameter, θ, by labour productivity, *i.e.*, manufacturing production divided by total hours worked in manufacturing. World income is estimated as a weighted average of manufacturing production in 21 OECD countries (all OECD countries except Iceland, Luxemburg, Mexico and Turkey), with the US dollar GDP for all sectors of the economy in 1980 used as weights (OECD: *Annual National Accounts*). Government spending is omitted as it is not available on a quarterly basis for most of the countries.

The foreign price in domestic currency, $E \cdot P^*$, is measured as a weighted index of the competitors prices in domestic currency in the export markets. The index is weighted with the degree of penetration of other OECD countries exports in the home producers' export markets. The weighting method is outlined by Duran [1986]. Data on $E \cdot P^*/P$, with manufacturing export unit values as deflators, are from Duran [1986] and are updated with data from IMF's *International Financial Statistics* and OECD's *Main Economic Indicators*. $E \cdot P^*/P$ is multiplied by producer prices of domestic manufactures to give $E \cdot P^*$.

The survey production expectations are measured as follows. National agencies conduct tendency surveys of manufacturing industries on a quarterly or monthly basis. The surveys cover a significant proportion of firms in the manufacturing sector and returns are prepared at senior management level or by a chief executive to guarantee reliability (OECD [1983]). The respondents are asked whether they expect production to increase, remain unchanged or decrease over the next three months. The data are quantified by subtracting the proportion of responses reporting lower from the proportion of responses reporting higher(3).

3.3 Estimation results

The results of estimating equation (5) are presented in table 1. The t-statistics in the table are modified to follow the standard t-distribution using the method described in Hamilton [1994, p 610]. The variables are cointegrated for all countries at the 5-percent level. This suggests that a reliable long-run relationship between the variables exists and implies that an error-correction representation of the model exists.

Most coefficients, which are significant at the 5-percent level, have their expected sign except the coefficients on financial wealth. Wages have the predicted negative influence on production and the wage elasticity is for most countries in the region of -0.25 and -0.50. The world production elasticity is about 0.50 for most countries, as we would expect, since this number approximately reflects the average propensity to export multiplied by the world income elasticity of exports. The sign of the coefficient on $(p^* + e)$ varies across countries; however, it is positive for most countries indicating that the demand effect tends to dominate the markup effect. The coefficients on money and credit are mostly positive, as expected. Finally, the coefficients on labour productivity, θ, are

(3) This method assumes that the responses are uniformly distributed. Other distributional assumptions have been used in the literature on inflation expectations. It is, however, uncertain which assumption is better (see, for instance, Defris and Williams [1979] and Foster and Gregory [1977]). The uniform distribution is used here as only balance number data, where the proportion reporting higher is subtracted from the proportion reporting lower, are readily available.

consistently positive reflecting positive long-run growth in manufacturing production.

Table 1: Parameter estimates of equation (5)

	w	a	y^*	$p^* + e$	m	cr	θ	ADF
Jap	−0.37 (3.98)	−0.01 (0.69)	0.30 (3.00)	0.24 (6.29)	0.19 (2.50)	−0.06 (1.56)	1.06 (13.0)	4.80
Aus	−0.45 (5.76)	−0.07 (3.58)	0.15 (1.05)	0.24 (4.33)	−0.02 (0.45)	0.20 (3.17)	0.58 (4.89)	5.75
Aut	−0.31 (2.04)	0.01 (0.84)	−0.19 (2.05)	0.00 (0.03)	0.12 (0.97)	0.12 (2.16)	0.92 (9.38)	5.44
Bel	0.05 (0.49)	0.00 (0.19)	0.49 (3.47)	−0.01 (0.25)	−0.14 (0.86)	0.11 (1.45)	0.06 (0.41)	6.74
Den	−0.43 (7.59)	−0.01 (1.05)	0.54 (5.40)	0.31 (5.73)	0.25 (3.64)	−0.10 (1.66)	0.54 (4.48)	7.21
Fin	−0.12 (1.08)	−0.03 (1.56)	0.08 (0.51)	0.08 (0.64)	0.24 (1.30)	0.03 (0.15)	0.25 (1.97)	5.76
Fra	−0.22 (1.55)	−0.08 (2.47)	0.74 (4.37)	−0.04 (0.59)	0.18 (0.98)	0.11 (2.29)	0.00 (0.01)	5.38
Ger	0.05 (0.26)	0.06 (1.36)	0.40 (2.12)	−0.14 (1.33)	−0.07 (0.58)	0.08 (0.65)	0.23 (1.19)	5.60
Ire	0.12 (1.08)	−0.11 (6.15)	0.66 (5.16)	−0.22 (4.19)	0.56 (7.29)	−0.23 (2.08)	0.61 (16.1)	6.02
Itl	−0.21 (1.98)	−0.08 (12.6)	−0.44 (3.82)	0.06 (1.17)	0.18 (2.13)	−0.01 (0.45)	1.43 (16.2)	6.16
Net	−0.11 (0.99)	−0.03 (1.01)	0.53 (3.10)	−0.04 (0.71)	0.27 (1.85)	−0.02 (0.34)	0.40 (0.19)	4.44
Spa	−0.23 (1.38)	−0.01 (0.15)	1.20 (5.07)	0.10 (1.03)	−0.35 (1.84)	0.53 (1.96)	0.06 (0.39)	5.14
Swe	0.08 (0.64)	0.09 (3.37)	0.62 (3.47)	−0.10 (1.37)	0.07 (0.29)	−0.27 (3.45)	0.20 (1.03)	5.18
Swz	−0.64 (6.28)	−0.02 (0.78)	0.17 (0.86)	0.43 (5.73)	0.21 (2.29)	0.03 (0.71)	0.83 (7.19)	5.18

Notes: Consistent asymptotic t-statistics in parentheses as described in the text.
ADF = augmented Dickey-Fuller test for cointegration with the dependent variable lagged one period. Estimation period: 1969.1Q-1994.4Q. AUS = Australia and AUT = Austria.

Table 2 presents the results of estimating equation (6). The diagnostic tests indicate a well specified model. Since the equations are used for forecasting it is an important to note that the predictive failure test is significant for only one country. White's heteroscedasticity consistent standard errors are used to compute the t-statistics for France, because the Breusch-Pagan test indicates heteroscedasticity. It is noteworthy that production expectations, share prices, world income and in particular the error-correction term tend to be significant predictors of production across countries. The remaining variables are insignificant: money supply, labour productivity, credit, wages and foreign prices in domestic currency. Another important feature of the estimates is that

Table 2: Parameter estimates of equation (6)

	Jap	Aus	Aut	Bel	Den	Fin	Fra
PE_{t-1} [(1)]	0.10 (6.16)	0.05 (3.55)			0.10 (4.11)	0.07 (4.67)	0.13 (5.67)
Δip_{t-1}							−0.71 (6.47)
Δip_{t-2}							−0.26 (2.41)
Δa_{t-1}	0.05 (2.12)						
Δy^*_{t-2}			0.51 (3.56)	0.11 (2.80)	0.40 (2.72)		
ε_{t-1}		−0.26 (3.10)	−0.43 (2.96)	−0.40 (5.32)	−0.42 (4.48)	−0.22 (3.90)	−0.23 (2.48)
BP	14.31	13.87	21.19	15.36	13.98	15.85	55.79
BG	1.28	0.54	1.45	0.70	0.67	2.07	0.76
PF	1.26	1.01	1.78	1.07	0.80	0.98	0.92
Chow	2.45	1.15	1.16	2.82	0.64	1.53	3.11
RESET	1.26	1.06	0.53	0.42	0.09	2.34	1.93
	Ger	**Ire**	**Itl**	**Net**	**Spa**	**Swe**	**Swz**
PE_{t-1} [(1)]	0.10 (5.95)		0.05 (3.13)				
Δip_{t-1}	−0.39 (5.53)	−0.37 (4.20)	−0.28 (2.72)	−0.46 (4.29)			−0.27 (2.44)
Δip_{t-2}		−0.33 (3.23)				0.26 (3.31)	
Δa_{t-1}		0.08 (2.83)				0.06 (2.71)	0.15 (2.71)
Δa_{t-2}		0.08 (3.61)		0.06 (2.47)			
Δy^*_{t-2}		0.65 (3.62)	0.40 (2.17)	0.59 (6.58)			0.40 (2.93)
ε_{t-1}	−0.26 (3.47)				−0.23 (2.92)	−0.27 (4.49)	−0.18 (1.93)
BP	14.92	21.17	17.07	30.43	13.86	15.61	20.08
BG	0.54	0.82	0.97	2.32	1.26	0.62	2.00
PF	1.06	1.58	0.63	0.53	1.46	3.50	0.41
Chow	1.25	1.40	1.09	0.90	1.82	2.88	1.85
RESET	4.14	1.43	1.31	0.00	1.13	1.61	1.50

Notes: t-statistics in parentheses using standard errors from White's heteroscedasticity consistent covariance matrix. Estimation period 1969.4Q-1992.2Q (the period 1992.3Q-1994.4Q are used to evaluate the forecasting ability of the model). BP = Breusch-Pagan test of heteroscedasticity with all explanatory variables in the original equation as regressors, $\xi^2(k)$-distributed under the null of homoscedasticity, where k is the number of explanatory variables, including the 7 deterministic variables, which are not shown in the table. The statistic BG = Breusch-Godfrey test for first to fourth order serial correlation, $F(4,81)$-distributed under the null of no serial correlation. The statistic PF = 10 period predictive failure test, $F(10,79)$-distributed under the null of parameter constancy in the last 10 periods. Chow = test of coefficient constancy (the sample was split in two subperiods, 1970.2Q-1980.1Q and 1980.2Q-1992.2Q), $F(10,60)$-distributed under the null of coefficient constancy. RESET = Ramsey's RESET test of the power of three for functional form, $F(2,78)$-distributed under the null of correct functional form.

(1) The coefficients on PE are multiplied by 100.

the magnitude of the significant coefficients on the same variables are quite similar across countries. These results, combined with the sound diagnostic tests, suggest that there exists a robust and reliable statistical relationships between the variables.

4 Model comparisons

The estimates of equation (6) in the previous section suggest that the macroeconomic model contains information that can be used in conjunction with production expectations to forecast changes in production. However, this result does not imply that equation (6) is necessarily a better forecasting model than a simple univariate model augmented with production expectations. It is essential to compare the models on the basis of their ability to forecast within and especially post sample criteria before it can be decided which is the best forecasting model.

Consider the following univariate model augmented with production expectations:

$$\Delta y_t = \nu_0 + \nu_1 PE_{t-1} + \nu_2 \Delta y_{t-1} + \nu_3 \Delta y_{t-2} + SD\phi + TSD\kappa + u_t. \quad (7)$$

Equation (7) is estimated over the same sample period as equation (6), and the period 1992.3Q-1994.4Q is used for post sample forecasting ability of the model. Table 3 displays two within sample model selection criteria: the adjusted multiple correlation coefficient (R^2) and Akaike's information criterion (AIC); and two post sample model selection criteria: mean squared error (MSE) and mean absolute error (MAE).

Table 3: Model selection criteria

	Equation (6)				Equation (7)			
	R^2	AIC	MSE	MAE	R^2	AIC	MSE	MAE
Jap	0.708	−7.648	0.053	2.021	0.641	−7.681	0.086	2.773
Aus	0.857	−7.567	0.052	1.599	0.845	−7.494	0.064	1.679
Aut	0.967	−7.575	0.057	2.411	0.962	−7.420	0.094	2.429
Bel	0.936	−7.598	0.062	2.223	0.924	−7.425	0.033	1.491
Den	0.825	−6.980	0.079	2.212	0.819	−6.949	0.110	2.781
Fin	0.970	−7.380	0.064	2.115	0.959	−7.170	0.093	2.407
Fra	0.978	−7.520	0.056	2.042	0.956	−7.903	0.083	2.630
Ger	0.955	−7.976	0.042	1.495	0.952	−7.903	0.062	1.639
Ire	0.891	−7.091	0.014	2.277	0.870	−6.904	0.112	2.534
Itl	0.899	−6.607	0.079	2.225	0.927	−6.911	0.100	2.480
Net	0.927	−6.903	0.057	1.890	0.954	−7.605	0.063	2.094
Spa	0.929	−6.906	0.146	3.269	0.927	−6.852	0.164	3.297
Swe	0.987	−7.544	0.219	3.947	0.986	−7.335	0.279	4.596
Swz	0.867	−6.624	0.061	1.981	0.852	−6.529	0.139	2.789

Notes: R^2 = multiple correlation coefficient adjusted for degrees of freedom, AIC = Akaike's information criterion, MSE = mean squared error multiplied by 100, MAE = mean absolute error multiplied by 100.

Most of the model selection criteria suggest that equation (6) is the best forecasting model. The adjusted R^2 gives preference to equation (6) for 12 out of the 14 countries, and AIC gives preference to equation

(6) for 11 countries. Both post sample criteria indicate that equation (6) is a better forecasting equation than equation (7) for all countries, except Belgium. Hence, the univariate forecasting model augmented with survey production expectations can be improved by exploiting the information contained in the reduced form macroeconomic model.

5 Conclusion

This paper suggests a simple method of combining the information contained in a reduced form macroeconomic model with survey production expectational data to improve the forecasts of production. Estimates of the model with data for 14 OECD countries indicate that the model has a better predictive performance than a simple univariate model augmented with survey production expectations.

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