Forecasting Trade Deflators In Ireland

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FORECASTING TRADE DEFLATORS IN IRELAND

Technical Note

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Executive Summary*

This technical note[1] provides an overview and rationale for recently developed forecast models for Irish export and import prices (trade deflators) in both Merchandise Goods and Services. These forecasts constitute a significant component of the GDP Deflator forecast used in the Department of Finance's overall macroeconomic forecast, produced for the annual Budget and the Stability Programme Updates.

New forecasting models for export and import prices were required due to recent revisions (July 2016) to the Central Statistics Office's (CSO) National Income and Expenditure (NIE) data series.

Based on the revised NIE quarterly data for the past 16 years (2000:Q1 – 2016:Q2), new short term forecasts of the trade deflators for Ireland over the period 2016:Q3- 2017:Q4 are presented at the end of this note.

The main results show that trade deflator forecasts presented here should be able to predict future export and import prices with a fair degree of accuracy (i.e. within one standard error bands). However, the forecasts quality is conditional on the absence of major turning points in the series, in particular for the Services trade deflators.

It should be noted that these models will be updated in line with the release of Quarterly National Account (QNA) and annual National Income and Expenditure data by the CSO. The next release, for 2016:Q3, is expected to be no later than December 23rd of this year.

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1. Introduction

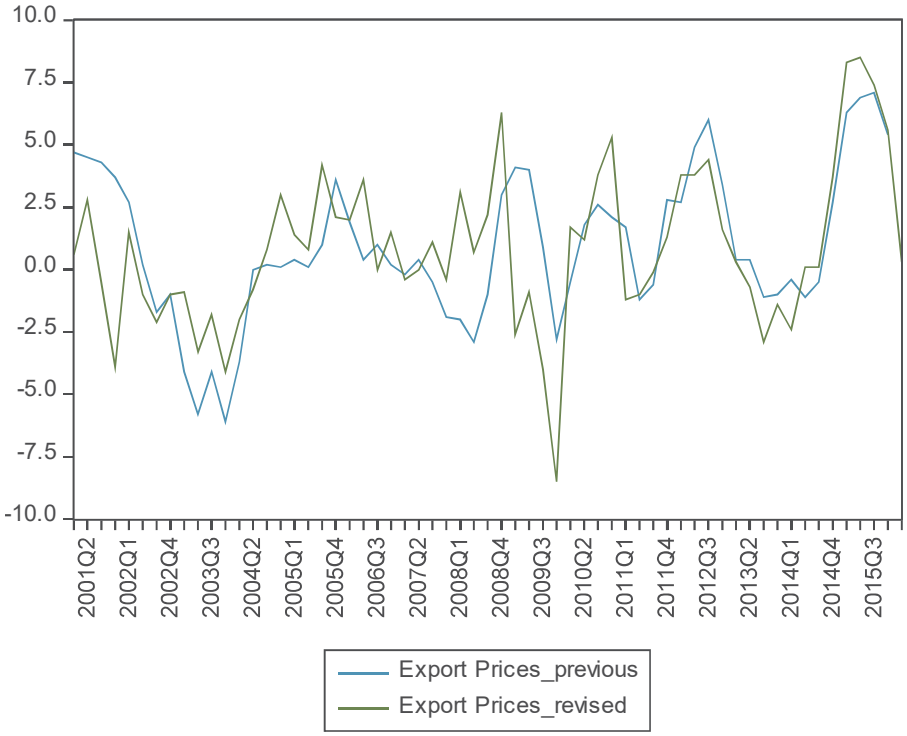
The aim of this technical note is to provide an overview and rationale for recently developed forecast models for Irish export and import prices (trade deflators) in both Goods and Services. These forecasts constitute a significant component of the GDP Deflator forecast used in the Department of Finance's overall macroeconomic forecast, produced for the annual Budget and for the Stability Programme Updates. New forecasting models for export and import prices were required due to recent revisions[2] (July 2016) to the Central Statistics Office's (CSO) National Income and Expenditure (NIE) data series. Moreover, revisions to the CSO's methodology for estimating both export and import prices were made at the same time.

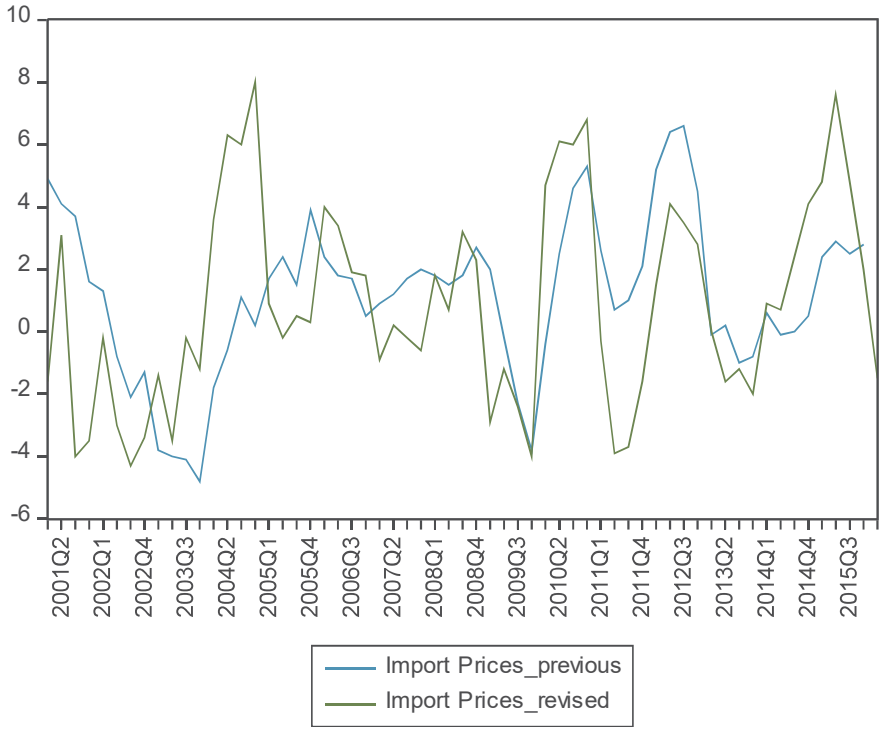
Based on the revised NIE data for the past 16 years (2000:Q1 – 2016:Q2), new short term forecasts of the trade deflators for Ireland over the period 2016:Q3- 2017:Q4 are presented at the end of this note. Details on the revised CSO methodology are not yet publicly available[3] but what can be seen is that the newly revised NIE data on both export and import prices can be distinguished from the old time series in two key aspects. Firstly, the revised series (green line) seems to be much more sensitive to small variations within the year and, as a result, it shows more volatility than the previous estimates (blue line); and secondly the new data seems to be more sensitive to extremes values and, as a result, it shows more pronounced peaks and troughs. For example, most of the well-publicised revisions in 2015 were due to changes on the import side (figure 1) and this was particularly evident for the import price of services (figure 8).

The outline of this technical note is as follows; section 2 is a brief literature review outlining different model specifications. Section 3 describes the data sources used for all four models (i.e. export and import prices for both Goods and Services) and gives a definition of the variables used in each of them. Section 4 provides the econometric results, including out-of-sample forecast evaluations. Section 5 presents short term forecasts of the trade deflators for Ireland over the period 2016:Q3- 2017:Q4. This technical note ends with some concluding remarks in section 6.

[2] http://www.cso.ie/en/releasesandpublications/er/na/quarterlynationalaccountsquarter12016/
[3] CSO information note on the calculation of merchandise trade indices forthcoming.

Figure 1: Export and Import prices (y-o-y % change)
pre- and post- revisions from 2001:Q1 to 2016:Q1





2. Model Specification

The model selection (i.e. choice of core variables) was based on the existing literature on import and export prices (Campa and Goldberg 2005, and also Kenny and McGettigann 1996, Doyle, 2004, Marazzi et al, 2007)[4]. The resulting trade price models tested the relationship between trade prices to exchange rates, foreign costs (including oil prices) among other factors identified as relevant for the Irish economy.

The model refinement (i.e. choice of proxies and lags) was based on the Box-Jenkins method -using the Akaike Information Criterion (AIC) and standard coefficient significance tests.

All the time series employed in the econometric analysis (i.e. year-on-year rate of change) were tested and found to be stationary, according to a combination of the Phillips-Perron and Augmented Dickey Fuller tests.

The final selection criteria for each of the models presented here is based on (i) goodness of fit (R^2>0.5); (ii) normally-distributed residuals; and (iii) no serial correlation evident in the residuals.

3. Definition of Variables and Data Sources

3.1 Definition of Variables

The main dependent/endogenous variables used in the forecasting models are;

- The export prices of goods (**XP_G**) and services (**XP_S)**
- The import prices of goods (**MP_G)** and services (**MP_S**)

While the main independent/exogenous variables are as follow:

- **HCI:** proxy of the nominal effective exchange rate. An increase in the index represents an appreciation of the local currency (i.e. a dis-improvement in competitiveness)
- **GBP:** GBP/EUR bilateral exchange rate. An increase in the ratio represents an appreciation of the euro.
- **USD:** USD/EUR bilateral exchange rate. An increase in the ratio represents an appreciation of the euro.
- **OIL:** spot oil prices expressed in euros per barrel.

In addition to the exogenous variables listed above, ARMA terms or lagged dependent variables were used to overcome the observed serial correlation that would be present in the models otherwise. A

[4] Campa, J. M. and Goldberg, L.S., (2005) "Exchange Rate Pass-Through into Import Prices". The Review of Economics and Statistics, 87(4): 679–690.
Kenny, G. and McGettigan D., (1996) "Exchange Rate Pass-Through and Irish Import Prices". Central Bank of Ireland Technical Paper, 6/RT/96.
Doyle, E., (2004) "Exchange rate pass-through in a small open economy: the Anglo-Irish case". Applied Economics, 2004, 36, 443–455
Marazzi, M., Sheets, N., and Vigfusson, R., and Faust, J., Gagnon, J., Marquez, J., Martin R., Reeve, T., and Rogers J. (2005) "Exchange Rate Pass-through to U.S. Import Prices: Some New Evidence. Board of Governors of the Federal Reserve System, International Finance Discussion Papers, Number 833.

large part of the serial correlation may arise from seasonal patterns in the non-seasonally adjusted imports and exports (value) series and as such the ARMA terms would be providing a rough seasonal adjustment to the non-seasonally adjusted data. Additionally, some serial correlation may also be accounted for by unexplained (non-seasonal) shocks in previous periods. ARMA terms include both autoregressive terms (AR) - normally significant when the past value of the residuals explain the current residuals and moving average terms (MA) - normally significant when past random shocks explain current values.

For one model (import service prices), autoregressive conditional heteroskedasticity terms (ARCH) were also considered – this is normally used to observe cluster (price) volatility in the time series.

All variables are measured as year-on-year annual rates of change, i.e. the percentage change with respect to the same quarter of the previous year.

3.1 Data Sources

Export and Import prices for both Goods and Services were obtained from the CSO's Quarterly National Accounts and calculated from the exports and imports constant and current value series.

The US Dollar and Pound Sterling to EUR exchange rates as well as the Harmonised Competitiveness Index (HCI) were obtained from the Central Bank of Ireland's website.

Oil prices used were ICE, Brent Crude daily close spot prices, expressed in euros per barrel. For all series, quarterly averages were calculated to convert to quarterly series.

The sample for the two export prices models (i.e. goods and services) and the Goods import prices models comprises 66 quarterly observations spanning from the first quarter of 2000 to the second quarter of 2016. The sample for the Service Import prices model estimation covered the period from quarter one 1999 to the second quarter of 2016 and hence comprises 70 quarterly observations.

4. Econometric Results

4.1 Goods Export Price Model

*XP_G = 0.24 + 0.30*MP_G - 0.23*USD + [AR(1)=0.19; MA(2)=0.76]*

Table 1: Goods Export Price - Output Table (ARMAX Model)

Dependent Variable: XP_G
Method: ARMA Maximum Likelihood (OPG - BHHH)
Included observations: 66
Convergence achieved after 26 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.241447	0.692681	0.348569	0.7286
MP_G	0.303442	0.068246	4.446260	0.0000
USD	-0.227078	0.046306	-4.903848	0.0000
AR(1)	0.198599	0.132165	1.502657	0.1382
MA(2)	0.755610	0.101702	7.429677	0.0000
SIGMASQ	6.076999	1.254748	4.843202	0.0000

R-squared	0.721261	Mean dependent var	0.227949
Adjusted R-squared	0.698033	S.D. dependent var	4.705016
S.E. of regression	2.585478	Akaike info criterion	4.851348
Sum squared resid	401.0819	Schwarz criterion	5.050407
Log likelihood	-154.0945	Hannan-Quinn criter.	4.930005
F-statistic	31.05104	Durbin-Watson stat	1.901064
Prob(F-statistic)	0.000000		

Inverted AR Roots	.20	
Inverted MA Roots	-.00+.87i	-.00-.87i

The constant term (C) in Table 1, which measures the rate at which export prices change, is non-significantly different from zero given the stationarity of the time series, as expected.
The table also shows that the change in goods export prices is accounted for by changes in the US Dollar/euro exchange rate, as expected, given that around half of Ireland's exports are denominated in dollars. In particular, an appreciation of 1 percentage point in the dollar (i.e. decline in the USD variable) would lead to an increase of 0.23 percentage points in the export price of goods with respect to the same quarter of the previous year.

More interestingly, the change in goods export prices seems to be correlated with changes in import prices (goods) that might be due to the strong presence of MNCs in Ireland's traded sector[5] . Attempts by large MNCs producers to optimise production has also resulted in increasing integration of Irish trade into Global Value Chains. One of the consequences of this phenomenon is that Ireland now

[5] According to the IMF, international trade between affiliated units is somewhere in the neighbourhood of 30 to 40 percent of world trade.

imports a high proportion of intermediate goods for use in producing its own exports[6] . In particular, the results indicate that a 1 percentage point increase in the import price of goods would lead to 0.3 percentage point increase in the export price of goods.

Lastly, changes in the export prices of goods seem to be explained by changes in the past values of the times series in two ways. On the one hand, the AR(1) terms would indicates that an annual change in export prices over the last quarter would have a positive, albeit low, impact (0.2) on the current quarter. However, the coefficient turns out to be non-significant at the 10% significance level. On the other hand, the MA(2) term suggests that a random shock in the previous two quarters is likely to have a significantly positive impact (0.76) on the current rate of change of export prices. This could be somehow reflecting "accounting" or "book-keeping" effects on behalf of MNCs as the US (October-September) and UK (April-March) have different fiscal years than their European counterparts (January-December).

Figure 2: Goods Export Prices – Goodness of fit
actual values vs. fitted values

Figure 2 shows that the fitted values of the model are relatively close to the actual observations, which is also in line with the fit of the model as measured by the R^2 (0.72). While a large R^2 is a good indication of how well the model fits past values, it does not necessarily mean that the model will be able to predict future values with the same degree of confidence.

To assess the forecast performance of the model, out-of-sample forecasts over two year horizons (8 quarters) were conducted at four different periods (2009:Q1 – 2010:Q4, 2011:Q1 – 2012:Q4, 2013:Q1–2014:Q4 and 2014:Q1–2015Q:4). A two-year horizon was chosen as this replicates the application of

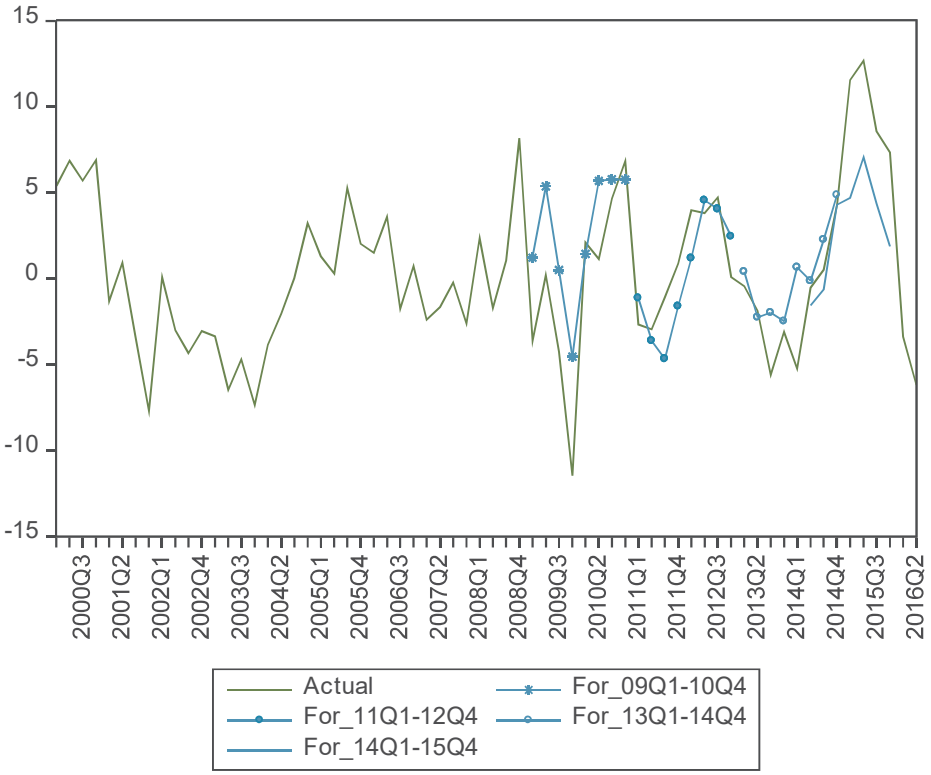
[6] S. Byrne and M. O'Brien (2015), "The Changing Nature of Irish Exports: Context, Causes and Consequences", Quarterly Bulletin 02 / April 15, Central Bank of Ireland.

the forecasting models for use in both the Budget and Stability Programme Update (SPU). Out-of-sample forecasts during these periods means forecast versus observed values can be compared and a forecast evaluation can be conducted.

The out-of-sample forecast evaluation (see figure 3) shows that the forecast values (blue lines) do not tend to deviate significantly from the actual values (green line).

The best out-of sample forecast period was 2011:Q1 – 2012:Q4 as it shows the lowest 'Root Mean Squared Error' (2.13) and 'Theil Inequality Coefficient' [7] (0.34) –including the lowest bias and variance proportions (see table 2). The fitted value of export prices still falls reasonably close to the actual values, even when evaluating the out-of-sample forecasts over the exceptional period 2014:Q1 – 2015:Q4, when goods export prices were particularly high. Overall the predictive power of the goods export price model seems to be reasonable as it catches significant turning points and the general trend.

Figure 3: Goods Export Price – Forecast evaluation
actual values vs. out of sample forecast values



[7] In forecast evaluation, among other prediction error measures, the 'Theil Inequality Coefficient' can be rescaled and decomposed into the bias, variance and covariance proportions. Note that the bias, variance, and covariance proportions add up to one. The larger the covariance proportion, the better the forecast evaluation.

Table 2: Goods Export Price – Forecast evaluation
Various statistics across forecast sub-samples

Forecast Sample	2009Q1 to 2010Q4	2011Q1 to 2012Q4	2013Q1 to 2014Q4	2014Q1 to 2015Q4
Root Mean Squared Error	4.247668	2.136299	2.564752	4.285631
Mean Absolute Error	3.638272	1.863537	1.755806	3.477958
Mean Absolute Percentage Error	410.6940	503.1566	104.8640	92.35663
Theil Inequality Coefficient	0.432935	0.344577	0.446503	0.357130
Bias Proportion	0.568599	0.107881	0.418769	0.658596
Variance Proportion	0.211433	0.031703	0.069571	0.193100
Covariance Proportion	0.219968	0.860415	0.511660	0.148304

4.2 Services Export Price Model

$$XP\_S = 0.8*XP\_S_{(t-1)} - 0.54*XP\_S_{(t-4)} + 0.62*XP\_S_{(t-5)} - 0.07*GBP_{(t-1)} + 0.30$$

Table 3: Services Export Price - Output Table (ARDL Model)

Dependent Variable: XP_S
Method: Least Squares
Sample (adjusted): 6 66
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.301460	0.380195	0.792910	0.4312
XP_S(-1)	0.796372	0.069820	11.40609	0.0000
XP_S(-4)	-0.542224	0.105418	-5.143581	0.0000
XP_S(-5)	0.624959	0.100424	6.223230	0.0000
GBP(-1)	-0.066761	0.033084	-2.017906	0.0484

R-squared	0.749409	Mean dependent var	3.290427
Adjusted R-squared	0.731510	S.D. dependent var	3.432944
S.E. of regression	1.778816	Akaike info criterion	4.068185
Sum squared resid	177.1944	Schwarz criterion	4.241208
Log likelihood	-119.0797	Hannan-Quinn criter.	4.135994
F-statistic	41.86794	Durbin-Watson stat	1.856945
Prob(F-statistic)	0.000000		

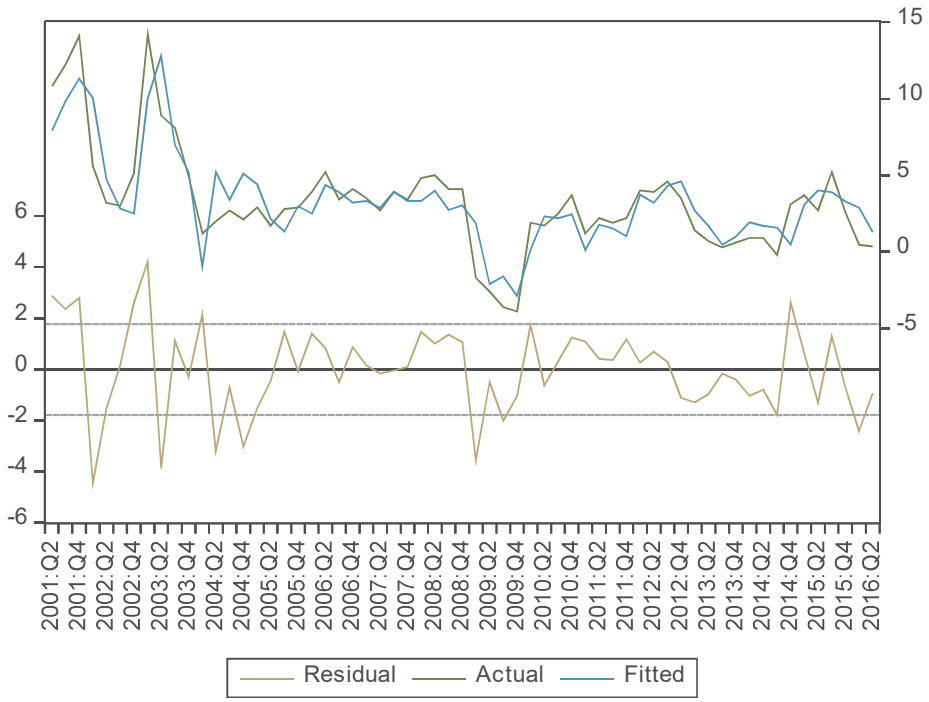
The export price of services in Ireland is largely determined by computer services which account for about half the total value of services exports, according to the CSO. In turn, a few MNCs account for a

large part of the ICT exports[8]. Therefore, export price of services in Ireland is likely to be influenced by sector- and firm-specific characteristic thus including their own past history, rather than a large number of exogenous macro variables. In this case, an autoregressive distributed lags model (ARDL) was found to be the most appropriate model choice to forecast the export price of services.

The output table 3 above shows that the present rate of change of service export prices is largely explained by their past values in the previous quarter [XP_S(-1) = 0.8], which might be reflecting a price-stickiness effect. There seems to be also a strong seasonal effect every one year or four quarters as the term XP_S(-4) turns out to be highly significant. Another seasonal effect in the export price of services can be seen every five quarter [XP_S(-5)], which is likely to be a result of the combined effect of both XP_S(-1) and XP_S(-4) lagged terms. Lastly, the one-quarter-lagged rate of change of the Pound Sterling to the euro exchange rate (GBP(-1)) is weakly correlated with the current change in export prices.

All the coefficients (with exception of GBP(-1)) are robust to the extreme services export prices observed at the beginning of the sample in 2001. Figure 4 shows that the goodness of fit improves in the outer quarters, however.

Figure 4: Services Export Price – Goodness of fit
actual values vs. fitted values



The out-of-sample forecast evaluation (figure 5) shows that the forecast service export prices (blue lines) do not tend to deviate significantly from the actual values (green line) when the series is near its mean. However, the forecast did not perform well during the dip in export prices over the 2009:Q1 to 2010:Q4 period or over the smaller dip from 2013:Q1 to 2014:Q4.

[8] According to ICT Ireland, 10 of the top 10 global technology companies, 9 of the top 10 global software companies as well as 4 of the top 5 IT services companies are located in Ireland (http://www.ictireland.ie)

Figure 5: Services Export Prices – Forecast evaluation
actual values vs. out of sample forecast values

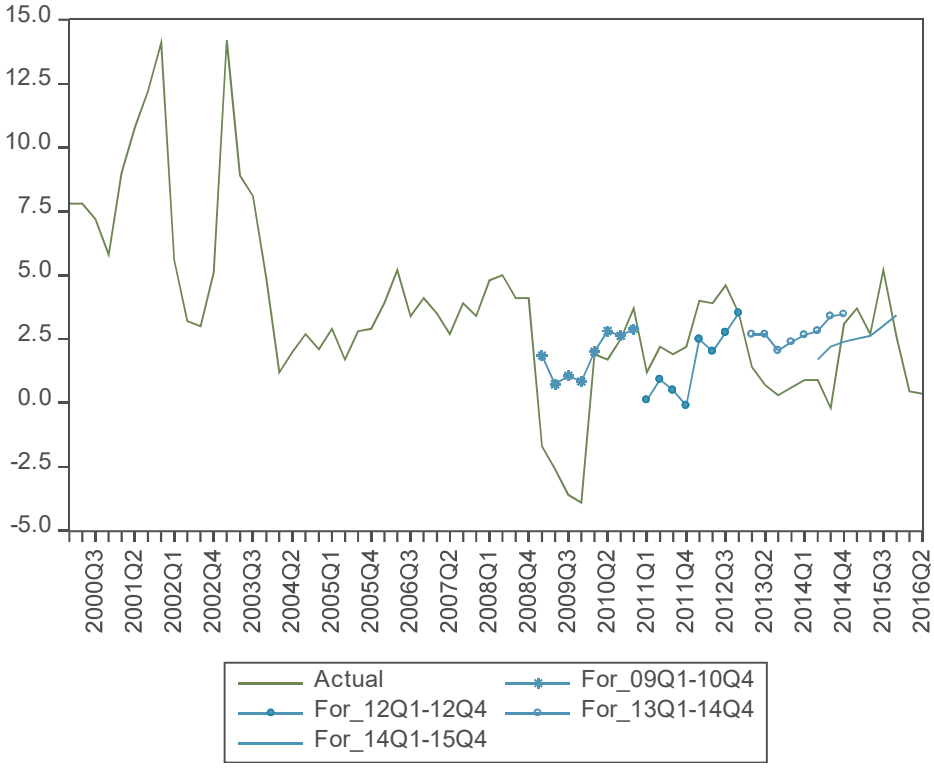


Table 4: Services Export Prices – Forecast evaluation
Various statistics across forecast sub-samples

Forecast Sample	2009Q1 to 2010Q4	2011Q1 to 2012Q4	2013Q1 to 2014Q4	2014Q1 to 2015Q4
Root Mean Squared Error	2.952564	1.556501	1.989360	1.404020
Mean Absolute Error	2.303504	1.418026	1.805438	1.169659
Mean Absolute Percentage Error	85.72282	56.78915	434.2527	203.4477
Theil Inequality Coefficient	0.606857	0.303636	0.481203	0.248112
Bias Proportion	0.506810	0.825456	0.823642	0.000151
Variance Proportion	0.453759	0.006357	0.057145	0.646135
Covariance Proportion	0.039431	0.168187	0.119212	0.353714

The forecast evaluation output shows that the forecast sample 2014:Q1 – 2015:Q4 result in the lowest 'Root Mean Squared Error' (1.4) and 'Theil Inequality Coefficient' (0.24) –including the larger covariance proportion (see table 4), indicating the forecast model performed best over this period. Overall, the predictive power of the services export price model seems to be reasonable outside of

periods that contain significant turning points. This is not surprising as these turning points are likely due to exogenous and industry specific factors for which there is limited or no data available.

4.3 Goods Import Price Model

*MP_G = 0.198 - 0.69*HCI + 0.04*OIL$_{(t-1)}$ + [AR(2)=0.51; AR(4)=-0.63; MA(1)=0.59]*

Table 5: Goods Import Price - Output Table (ARMAX Model)

Dependent Variable: MP_G
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 09/21/16 Time: 16:20
Sample: 2000Q2 2016Q2
Included observations: 65
Convergence achieved after 25 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.198232	0.788992	0.251247	0.8025
HCI	-0.685129	0.159592	-4.293013	0.0001
OIL(-1)	0.038105	0.020209	1.885545	0.0644
AR(2)	0.513611	0.129543	3.964797	0.0002
AR(4)	-0.628030	0.092443	-6.793722	0.0000
MA(1)	0.593035	0.126858	4.674780	0.0000
SIGMASQ	11.85197	2.277036	5.205001	0.0000

R-squared	0.713757	Mean dependent var	0.199960
Adjusted R-squared	0.684146	S.D. dependent var	6.484769
S.E. of regression	3.644500	Akaike info criterion	5.563172
Sum squared resid	770.3782	Schwarz criterion	5.797337
Log likelihood	-173.8031	Hannan-Quinn criter.	5.655565
F-statistic	24.10416	Durbin-Watson stat	1.984175
Prob(F-statistic)	0.000000		

Inverted AR Roots	.72+.52i	.72-.52i	-.72+.52i	-.72-.52i
Inverted MA Roots	-.59			

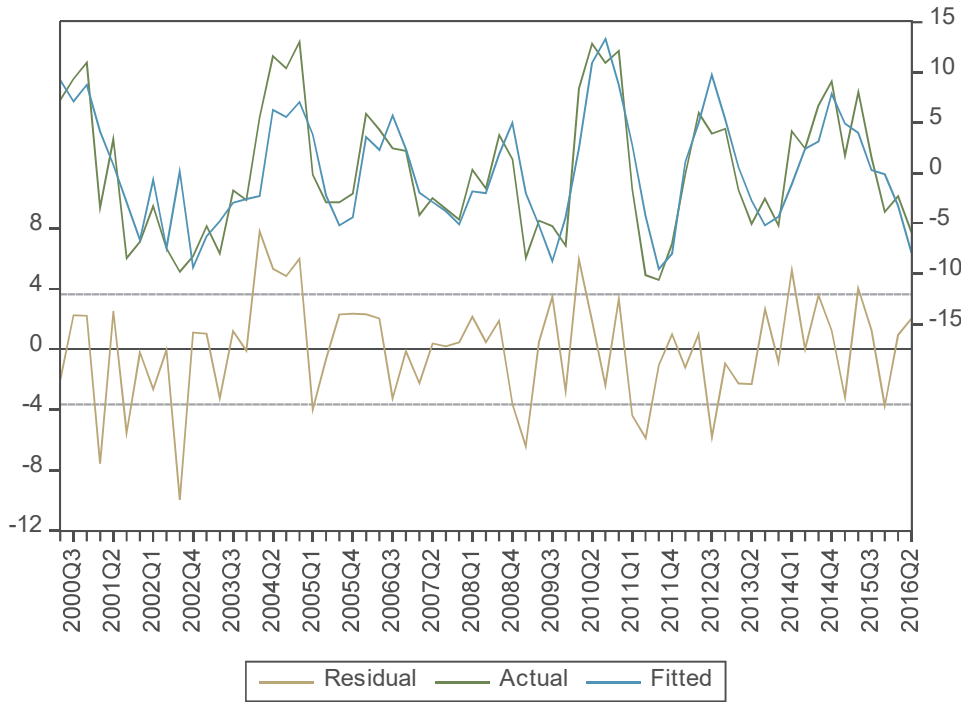
The model's results indicate that year-on-year changes in goods imports prices are explained by year-on-year changes in; the HCI (-0.68), a one-quarter lag of Oil prices (0.03) and a parsimonious ARMA(4,1) structure consistent with a seasonal adjustment correction. Both the exogenous coefficients have the expected sign, whereby, changes in goods import prices are negatively correlated to changes in the HCI and positively, albeit weakly, correlated with changes in oil prices (which is only significant at the 10 per cent level).

According to theory, foreign prices (e.g. HICP price indices weighted using trading partner export volumes) are usually employed as one of the main explanatory variables driving import prices of goods. However, post the NIE revision, foreign prices were either found not to be statistically significant or significant but negatively correlated with goods import prices, depending on the model specification

used. As a robustness check, foreign prices constructed using unit labour costs were also tested and consistently found to be negatively correlated (and statistically significant) with goods import prices[9].

The R^2 of 0.71 indicates a satisfactory goodness of fit, which is also evident in the fitted versus actual values graph below (figure 6). The fit to historical data performs well even in years of exceptionally high year-on-year changes in export prices (i.e. 2004, 2010 and 2015).

Figure 6: Goods Import Prices – Goodness of fit
actual values vs. fitted values



With respect to the forecast evaluations, the results of the out-of-sample forecasts over four different periods can be seen in figure 7 and in table 6 below. Figure 7 shows that the forecasts generally performs reasonably well, with the forecasts capturing significant turning points and matching the general trend.

As explained earlier, a forecast is generally "good" if the bias and variance proportions are small and most of the bias is concentrated in the covariance proportion. While this is true for the period 2014:Q1-2015:Q4, for the remaining out-of-sample periods the bias and variance variations are relatively large (see table 6). In all cases, however, the Theil statistic is well below unity, suggesting a reasonably 'fair' predictive power of the model.

[9] A negative correlation between Irish import prices and UK production costs has been previously found (pre NIE revision) for certain (ISIC) sectors over the short run, one quarter (Doyle, 2004). One possible explanation is that the NIE revision may have resulted in these sectors (e.g.: Food, beverages and tobacco; Textile, wearing apparel and leather; and Fabricated metal products, machinery and equipment) making a larger contribution in the revised aggregate series.

Figure 7: Goods Import Price – Forecast evaluation
actual values vs. out of sample forecast values

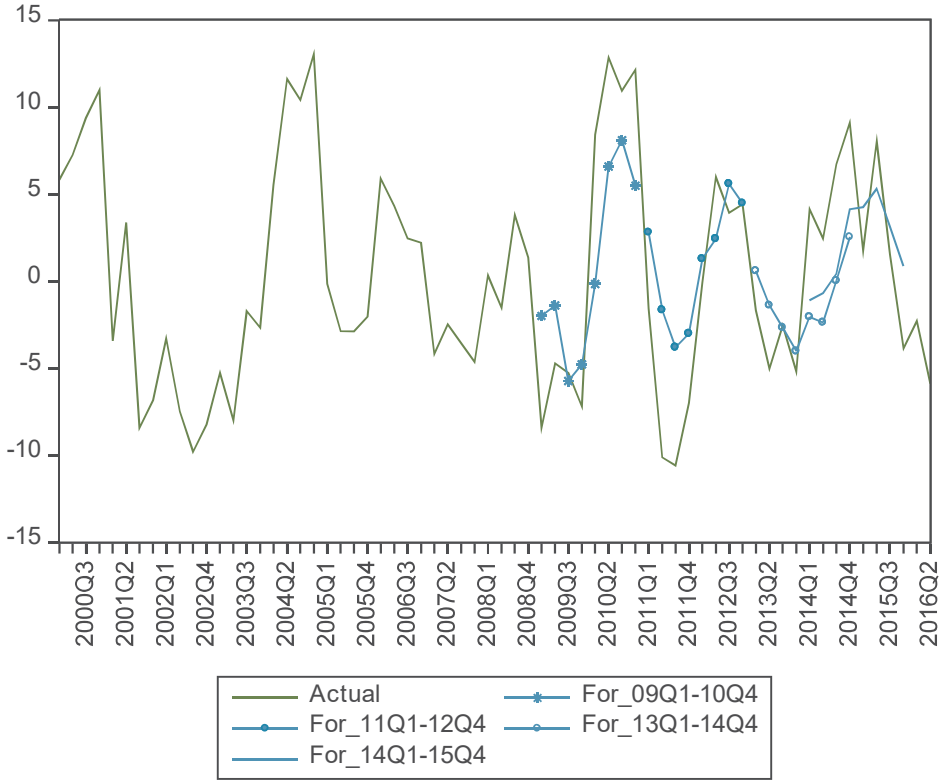


Table 6: Goods Import Prices – Forecast evaluation
Various statistics across forecast sub-samples

Forecast Sample	2009Q1 to 2010Q4	2011Q1 to 2012Q4	2013Q1 to 2014Q4	2014Q1 to 2015Q4
Root Mean Squared Error	5.290714	4.612947	4.607359	4.187701
Mean Absolute Error	4.624828	3.782205	3.939382	3.901187
Mean Absolute Percentage Error	52.55582	277.6424	94.21820	101.0160
Theil Inequality Coefficient	0.372412	0.465734	0.618125	0.492246
Bias Proportion	0.089346	0.393739	0.222195	0.164054
Variance Proportion	0.555234	0.411095	0.452323	0.154276
Covariance Proportion	0.355421	0.195166	0.325482	0.681670

4.4 Services Import Price Model

$$MP\_S = 2.21 - 0.28*HCI + [AR(1)=0.66]$$

$$GARCH = 0.12 - 0.16*RESID(-1)^2 + 1.1*GARCH(-1)$$

The import price of services in Ireland (as of 2015) are mostly determined by three categories: royalties/licences[10] (45%); misc. business services (25%) –including advertising and intra-firm management charges; and research and development (13%). These categories, in particular, host a number of MNCs which tend to dominate Ireland's services import sector. Therefore, similar to the services export sector, the import price of services is likely to be influenced by large firm-specific characteristics, leading to price-stickiness in the series.

Table 7: Services Import Price - Output Table (ARX-GARCH Model)

Dependent Variable: MP_S
Method: ML - ARCH
Sample (adjusted): 1999Q2 2016Q2
Included observations: 69 after adjustments
Convergence achieved after 54 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.209824	0.472898	4.672942	0.0000
HCI	-0.277484	0.058805	-4.718683	0.0000
AR(1)	0.658357	0.000711	925.5600	0.0000
Variance Equation				
C	0.115460	0.042707	2.703572	0.0069
RESID(-1)^2	-0.157226	0.046034	-3.415436	0.0006
GARCH(-1)	1.100565	0.065802	16.72529	0.0000

R-squared	0.514334	Mean dependent var	2.584890
Adjusted R-squared	0.499617	S.D. dependent var	2.337550
S.E. of regression	1.653530	Akaike info criterion	3.594832
Sum squared resid	180.4546	Schwarz criterion	3.789103
Log likelihood	-118.0217	Hannan-Quinn criter.	3.671906
Durbin-Watson stat	2.419459		

Inverted AR Roots	.66

The mean year-on-year changes in services imports prices are explained by year-on-year changes in the HCI (-0.28) and an AR(1) term (0.66) [11].

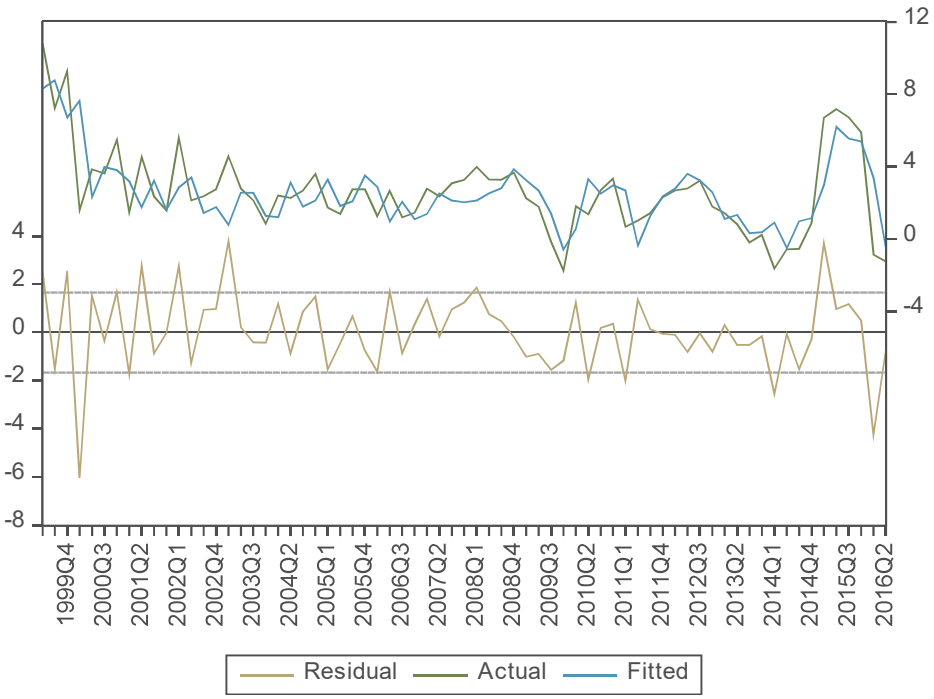
The conditional variance of the series is additionally modelled adding a GARCH(1,1) structure, which is used in an attempt to better understand the different volatility patterns observed in the services

[10] This category grew by 40% with respect to 2014, according to the CSO.
[11] As discussed for the Service export price model, data limitations are again a major constraint in investigating Services import price trends in more detail.

imports prices before and after the 2008-09 crisis. In other words, the variance equation includes news about volatility from the previous period [RESID(-1)^2] as well as the last period's forecast variance [GARCH(-1)].

All coefficients in the mean and variance equations, including the intercept[12], are statistically significant (at the 5% significance level) and the exogenous coefficient (HCI) has the expected negative sign.
Considering the parsimony of the model which includes very few explanatory variables, an R^2 of 0.51 would indicate a reasonable goodness of fit. From the fitted versus actual values graph (figure 8) below, the fit to historical data performs relatively well across the sample period, even during the exceptionally high year-on-year price changes in 2015.

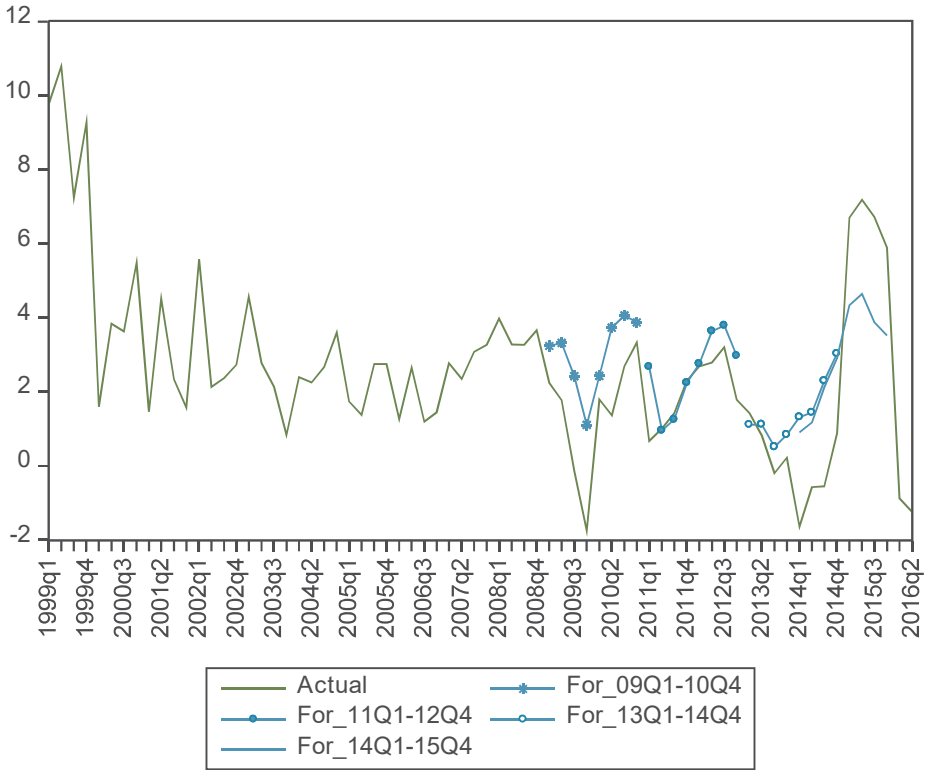
Figure 8: Services Import Price – Goodness of fit
actual values vs fitted values



As with the previous models, to assess forecast performance, out-of-sample forecasts over two-year horizons (8 quarters) were conducted at four different periods (2009:Q1 – 2010:Q4; 2011:Q1 – 2012:Q4; 2013:Q1-2014:Q4; and 2014:Q1-2015:Q4). Figure 9 shows that the mean forecasts generally perform reasonably well during period of low volatility (i.e. 2011-2012) but not during periods of large variations from the mean trend (i.e. 2009–2010, 2013-2014 and 2014–2015).

[12] The Services Import prices and HCI series were both tested and found to be stationary.

Figure 9: Services Import Prices – Forecast evaluation
actual values vs. out of sample forecast values



The forecast evaluation in Table 8 shows that the most accurate estimates are to be found in the period 2011:Q1 – 2012:Q4, where all the statistics show low values relative to other periods. Nonetheless, the Theil statistic shown for all periods is below unity suggesting a reasonable predictive power of the model, in the absence of major turning points.

Table 8: Services Import Price – Forecast evaluation
Various statistics across forecast sub-samples

Forecast Sample	2009Q1 to 2010Q4	2011Q1 to 2012Q4	2013Q1 to 2014Q4	2014Q1 to 2015Q4
Root Mean Squared Error	1.813624	0.901813	1.823447	2.415014
Mean Absolute Error	1.610224	0.619428	1.489201	2.464451
Mean Absolute Percentage Error	297.6871	54.55795	248.6337	172.1082
Theil Inequality Coefficient	0.346104	0.185654	0.709694	0.312704
Bias Proportion	0.788276	0.372248	0.598402	0.002740
Variance Proportion	0.111671	0.013489	0.007717	0.914378
Covariance Proportion	0.100053	0.614263	0.393881	0.082882

5. Forecasting Results 2016-2017

Forecasts for the period 2016:Q3- 2017:Q4 were conducted to assess the impact of both the NIE revisions and using the updated forecast models.

Table 9: Export and import prices forecasts (goods and services[13])
Actual (2015:Q1- 2016:Q2) vs forecast (2016:Q3- 2017:Q4)[14]

y-o-y %	Export Prices			Import Prices			Terms of Trade		
	Goods	Services	Total	Goods	Services	Total	Goods	Services	Total
2015:Q1	11.6	3.7	8.3	1.7	6.7	4.8	9.7	-2.8	3.4
2015:Q2	12.7	2.7	8.5	8.0	7.2	7.6	4.3	-4.2	0.8
2015:Q3	8.6	5.2	7.4	1.5	6.7	4.8	6.9	-1.4	2.5
2015:Q4	7.3	2.6	5.6	-3.9	5.9	2.0	11.7	-3.1	3.4
2015	**10.0**	**3.6**	**7.4**	**1.9**	**6.6**	**4.8**	**8.0**	**-2.9**	**2.5**
2016:Q1	-3.4	0.5	-2.0	-2.3	-0.9	-1.3	-1.1	1.4	-0.7
2016:Q2	-6.2	0.4	-3.6	-5.9	-1.2	-2.8	-0.3	1.6	-0.8
2016:Q3	-3.3	-1.2	-2.4	-0.4	-0.1	-0.2	-2.9	-1.0	-2.3
2016:Q4	-4.0	0.0	-2.4	0.4	0.4	0.4	-4.4	-0.4	-2.8
2016	**-4.2**	**-0.1**	**-2.6**	**-2.0**	**-0.5**	**-1.0**	**-2.2**	**0.4**	**-1.7**
2017:Q1	-0.6	0.5	-0.2	1.0	1.2	1.1	-1.6	-0.7	-1.3
2017:Q2	1.5	0.1	1.0	4.2	1.7	2.5	-2.5	-1.5	-1.5
2017:Q3	0.0	0.7	0.2	-0.2	1.9	1.1	0.2	-1.2	-0.9
2017:Q4	0.3	0.1	0.2	0.4	2.0	1.4	-0.1	-1.9	-1.2
2017	**0.3**	**0.3**	**0.3**	**1.3**	**1.7**	**1.5**	**-1.0**	**-1.3**	**-1.2**

Ireland's export deflator (year-on-year change in export prices - Total[15]) is forecast to be -2.6 per cent in 2016 – including two outturn data points in the first half of the year. The negative forecasts in the second half of the year are reflecting the change of trend with respect to 2015, when the export deflator growth was 7.4 per cent. In 2017, export prices are forecast to (slightly) increase again at 0.3 per cent on average.

Import prices (total) are forecast to decrease by 1.0 per cent this year –including outturn data for the first half of 2016 - with respect to 2015, when they had increased by 4.8 per cent. Import prices are expected to grow again at 1.5 per cent in 2017, with respect to the previous year.

Overall, Ireland's terms of trade (i.e. the ratio between export and import prices) are expected to deteriorate in 2016 by 1.7 per cent, with respect to the previous year when they had recorded an exceptional improvement of 2.5 per cent, largely due to foreign exchange movements of the euro. In 2017, the terms of trade are expected to deteriorate again although at a slower pace (-1.2 per cent).

[13] Unweighted series
[14] For the purposes of the Budget 2017 forecasts, adjustments based on economic judgment were made to the model forecasts within the range of the forecast confidence bands.
[15] The total value is the weighted average of both goods and services series in 2015.

5.1 Export Price Forecasts

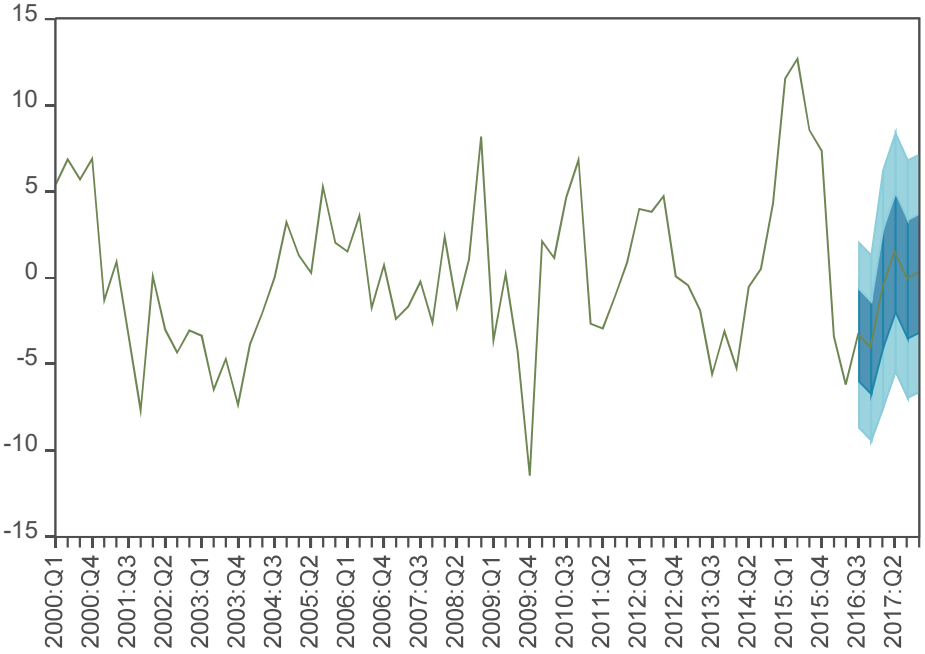
The year-on-year change in the export price of goods is forecast to be -4.2 per cent in 2016, which is largely attributed to the (actual) change in the second quarter of 2016 (-6.2 per cent) with respect to the same quarter in 2015 when the export goods deflator was exceptionally high (12.7 per cent).

In 2017, the year-on-year change in the export price of goods is forecast to be positive again at 0.3 per cent. This is largely attributed to the expected change in the second quarter of 2017 (1.5 per cent), which is reflecting the same seasonal pattern observed in 2016.[16]

The export price of services is forecast to decrease slightly by 0.1 per cent in 2016, which is largely attributed to the predicted decline of 1.2 per cent in the third quarter of the year with respect to the same quarter in 2015, when the services export price growth was exceptionally large at 5.2 per cent.

In 2017 services export prices are forecast to grow again at 0.3 per cent, with positive growth rates in every quarter of the year, probably reflecting the price-stickiness effect that prevails in the ICT sector.

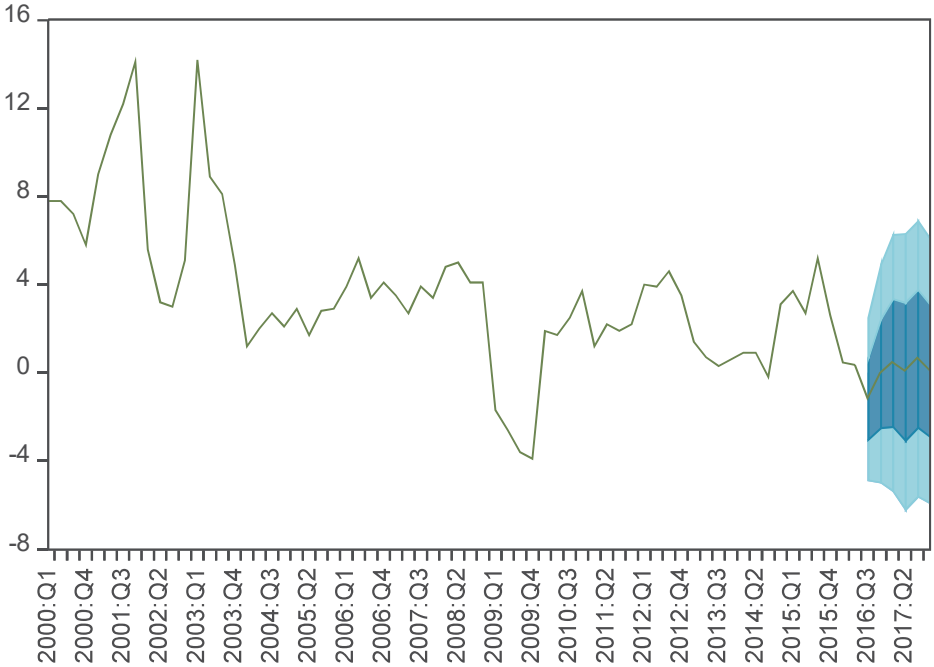
Figure 10: Export Price of Goods – y-o-y %
Actual (2000:Q1-2016:Q2) vs forecast (2016:Q3-2017:Q4)



Figures 10 and 11 show the change in the export prices of goods and services, respectively, between the first quarter of 2000 and the second quarter of 2016. The series are further expanded to include the mean forecasts between the third quarter of 2016 and the fourth quarter of 2017, including density forecasts (i.e. fan charts) that illustrate the probability distributions of future prices. The fan charts are estimated using plus/minus one standard errors (dark blue area) and plus/minus two standard errors (light blue area) from the models. The mean forecast value is expected to fall within the bands in 68 out of 100 cases (dark blue area) and 95 out of 100 cases (light blue area), which is being used as a measure of forecasting accuracy.

[16] A similar pattern is found in the import price of goods, which enters into the goods export price equation.

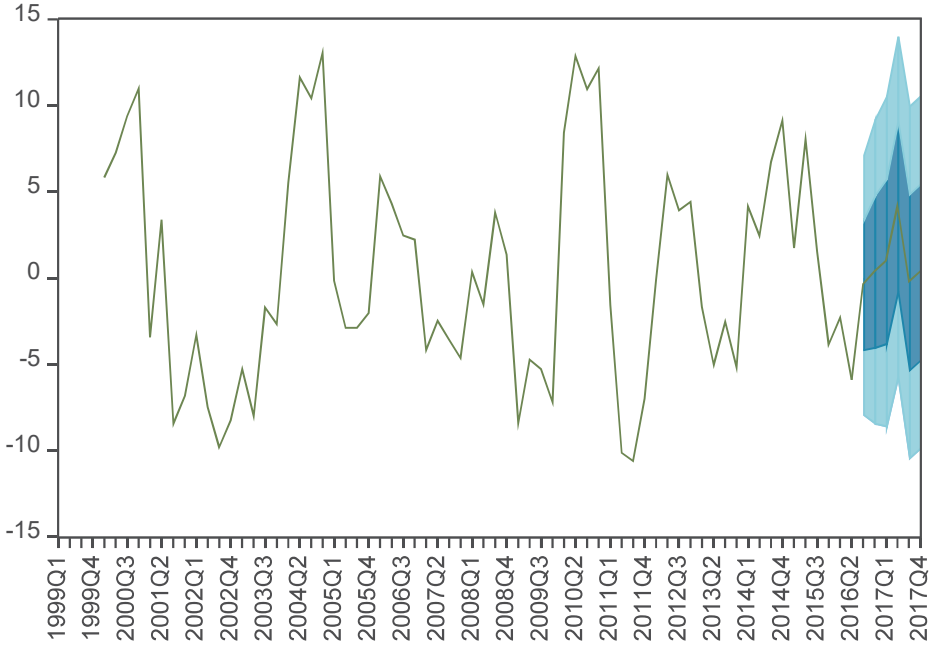
Figure 11: Export Price of Services - y-o-y %
Actual (2000:Q1-2016:Q2) vs forecast (2016:Q3-2017:Q4)



5.2 Import price forecasts

The year-on-year change in the import price of goods is forecast to be -2.0 per cent in 2016 – including two outturn data points in the first half of the year. This is largely attributed to the actual change in the second quarter of 2016 (-5.9 per cent) with respect to the same quarter in 2015 when the import prices of goods were exceptionally high at 8 per cent.

Figure 12: Import Price of Goods – y-o-y %
Actual (2000:Q1-2016:Q2) vs forecast (2016:Q3-2017:Q4)

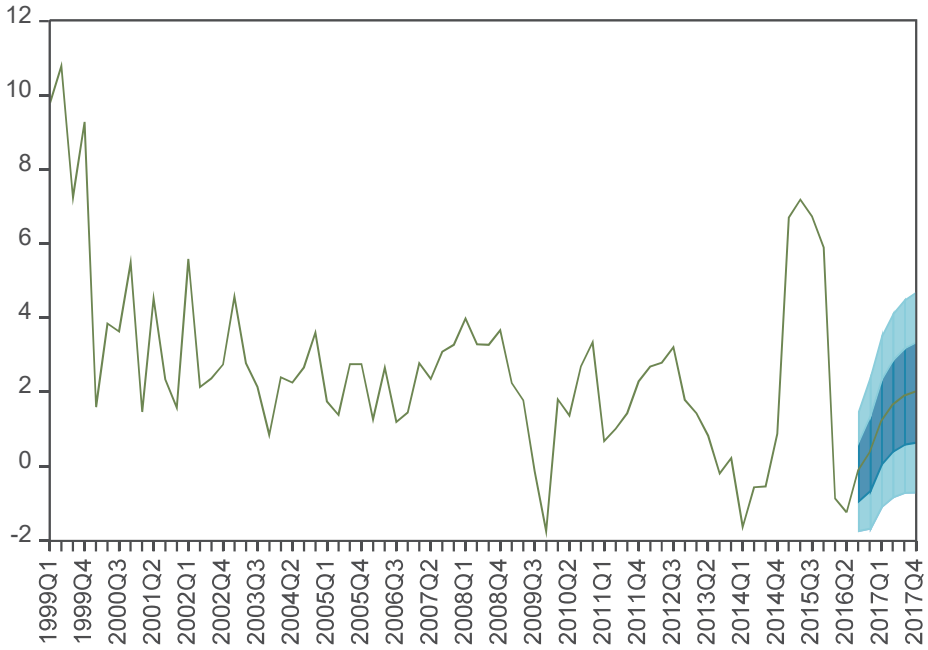


In 2017, however, the year-on-year change in the import price of goods is forecast to be up to 1.3 per cent. This is largely attributed to the predicted change in the second quarter of 2017 (4.2 per cent), which is reflecting the same seasonal pattern observed in 2016.

Overall, the goods import price forecasts show a marked quarterly volatility that is well captured by the forecasting model (figure 12 above).

Similar to services exports, the year-on-year change in the import price of services is forecast to be slightly negative -0.5 per cent in 2016, down from the exceptional growth of 6.6 per cent in 2015. The yearly decline in the import price of services is largely attributed to the (actual) drop of 1.2 per cent in the second quarter of the year. Afterwards, however, the year-on-year change in services import prices is forecast to gain strength averaging 1.7 per cent in 2017. The smooth quarterly profile observed in Figure 13 is due to the fact that the main explanatory variable in the forecasting model is HCI, which is assumed to remain constant in the later quarters (i.e. a naïve forecast).

Figure 13: Import Price of Services – y-o-y %
Actual (2000:Q1-2016:Q2) vs forecast (2016:Q3-2017:Q4)



6. Concluding Remarks

The aim of this technical note is to introduce new forecasting models for Irish export and import prices (trade deflators) in both Merchandise Goods and Services in the light of the well-publicised recent revisions17 (July 2016) to the Central Statistics Office's (CSO) National Income and Expenditure (NIE) data series. These trade deflator forecasts constitute a significant component of the GDP Deflator forecast used in the Department of Finance's overall macroeconomic forecast, produced for the annual Budget and the Stability Programme Updates.

Following the established literature on export and import prices, a number of forecasting models were specified and tested ahead of the 2016-2017 quarterly forecasts required for Budget 2017. The main results show that the trade deflator forecasts presented here should be able to predict future export and import prices with a fair degree of accuracy in 68 out of 100 cases (i.e. within one standard error bands). However, the forecast quality is conditional on the absence of major turning points in the series, in particular for the Services trade deflators.

One of the main contribution of this note to trade deflators forecasting is the inclusion of import prices into the export prices equation to account for the growing share of intermediate goods import into Ireland's export of final goods, which turned out to be highly significant.

Nonetheless, one the most puzzling findings is the fact that foreign inflation turned out to be either not correlated or significant but negatively correlated with the import prices of goods under different specifications. As Doyle (2004) pointed out, this could be indicating that exporters in some sectors decided not to pass on changes in their wage costs into the price they received from Irish importers in order to retain market share in the short term. However, further research is required to understand why this unexpected relationship still holds in the long run.

Moreover, service trade deflators were modelled and forecasted using mostly autoregressive terms (e.g. ARMA) due to data constraints. Notwithstanding that, both service export and import models indicate some price-stickiness effect in Ireland's traded service sector, which is largely dominated by MNCs. Further research may be required to understand the rationale behind many of the seasonal components found in forecasting models for trade deflators, including an analysis of impulse-response function to shed light on their likely impact on import and export price forecasts.

Finally, it should be noted that these models will be updated in line with the release of Quarterly National Account (QNA) and National and Income Expenditure data by the CSO. The next release, for 2016:Q3, is expected to be no later than December 23rd of this year.

[17] http://www.cso.ie/en/releasesandpublications/er/na/quarterlynationalaccountsquarter12016/

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