Identifying and Adjusting for Sudden Changes in Seasonal Patterns

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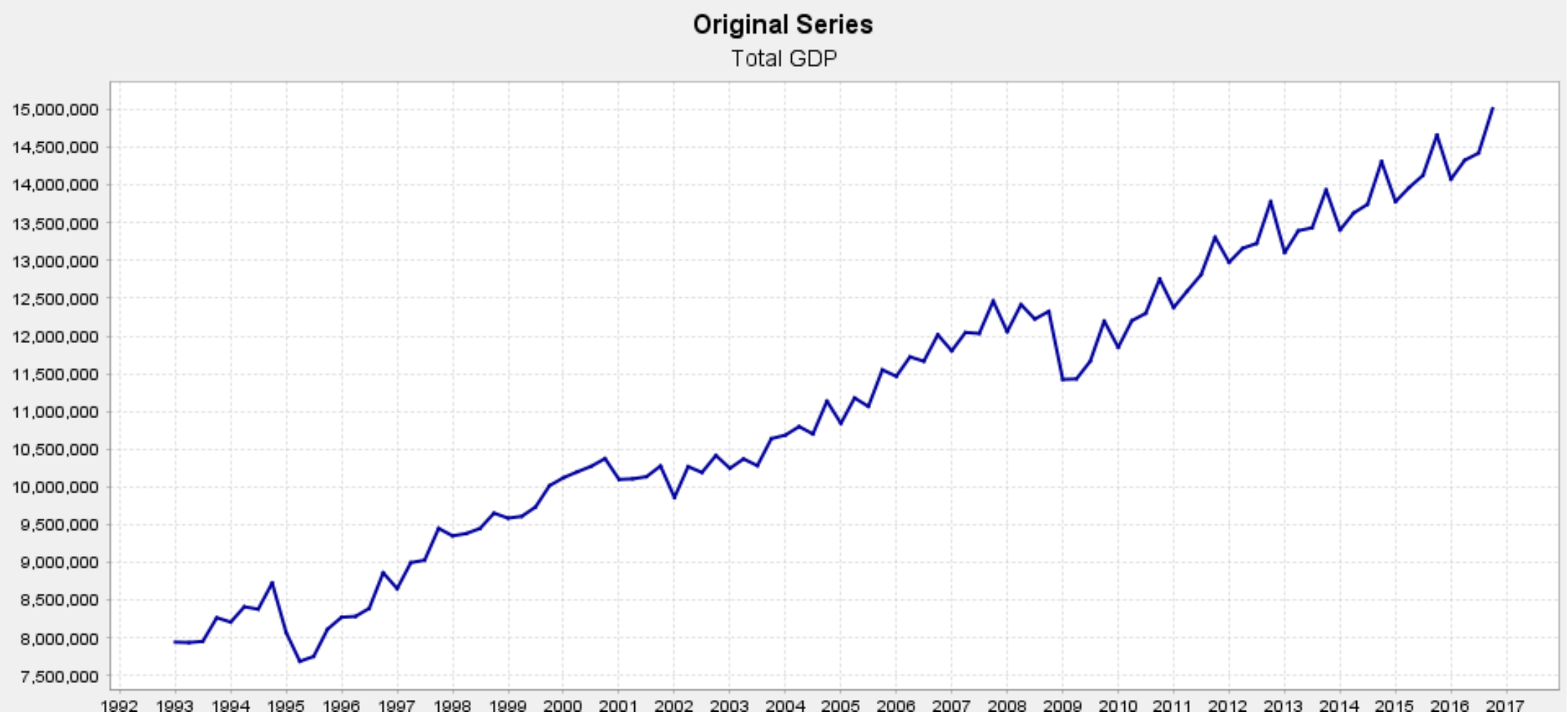
Disclaimer: Any views expressed here are those of the author and not those of the U.S. Census Bureau.

Sudden changes in the seasonal pattern

- A change in an established series can result in an abrupt change in the seasonal pattern
  - Recession, pandemic, survey methodology, sector activity
- X-13ARIMA-SEATS (X-13) can test for a change in the overall seasonal pattern or in a specific month/quarter
- If there is a significant change, there is a way to impose that sudden change directly onto the seasonal factors

Example: Mexico GDP



Change-of-regime seasonal regressors

seasonal regressors: 11 monthly/3 quarterly regressors. SR(m,t) = 1 if t is in month m, -1 if t is December/Q4, and 0 otherwise.

Partial change-of-regime seasonal regressors:

seasonal//yyyy.mm/ : before yyyy.mm, seasonal regressors are zero. On and after yyyy.mm, regular seasonal regressors are used

seasonal/yyyy.mm// : before yyyy.mm, regular seasonal regressors are used. On and after yyyy.mm, seasonal regressors are zero

Full change-of-regime seasonal regressors:

seasonal/yyyy.mm/ : one set of regular regressors and a set of seasonal/yyyy.mm// regressors are added

Testing for a change in the seasonal pattern

- Identify the date the change may have started – yyyy.mm
- Insert change-of-regime seasonal regressors into the spec file:

```
regression{
        variables = ( seasonal//yyyy.mm/  [other regressors] )
}
```

  - You could instead use seasonal/yyyy.mm//
  - Unlike regular seasonal regressors, this can be used along with a seasonal difference so the ARIMA model does not need to change
  - If the series is being modeled with seasonal regressors, use seasonal/yyyy.mm/
- Check output file for the p-value of the F test for Seasonal (starting yyyy.mm)
  - Seasonal (before yyyy.mm) if using seasonal/yyyy.mm//
  - Seasonal (change for before yyyy.mm) if using seasonal/yyyy.mm/

Example: Mexico GDP
Test for the change in 2009.1

- Original spec had

  transform{ function = none }

  regression{ variables = (td1coef easter[1] AO1995.1 LS1995.1) }

  arima{ model = (0 1 1)(0 1 1) }

- Add a level shift in 2009.1 and the partial change-of-regime seasonal regressors

  transform{ function = none }

  regression{ variables = (td1coef easter[1] AO1995.1 LS1995.1 LS2009.1

  seasonal//2009.1/) }

  arima{ model = (0 1 1)(0 1 1) }

Example: Mexico GDP
Output file tables

Regression Model

	Parameter Estimate	Standard Error	t-value
1 Coefficient Trading Day			
[illegible]	[illegible]	[illegible]	[illegible]
LS2009.1	-590585.6208	94930.53465	-6.22
Seasonal (starting 2009.1)			
@ 1st II	-39843.9978	47412.56014	-0.84
@ 2nd II	-152976.5500	44245.44552	-3.46
@ 3rd II	9171.7614	44104.90017	0.21
* 4th II (derived)	183648.7864	45780.00545	4.01

F Tests for Seasonal Regressors

	df	F-statistic	P-Value
Seasonal (starting 2009.1)	3, 82	5.22	0.00

Applying the change to the seasonal factors (X-11): Creating a file of regressors

- Run the spec file with no regressors other than the seasonal//yyyy.mm/.
  - Turn off outlier identification.
  - Extend the forecast window if you intend to use this in production.
  - Add save=rmx to the regression spec.
  - Run with an alternate output name (or change the name of the .rmx file later)
- The resulting *.rmx file will be in x13save format, and is the regression matrix for the 11 (monthly) or 3 (quarterly) change-of-regime seasonal regressors.

Applying the change to the seasonal factors (X-11): Running with user-defined seasonal regressors

- Edit the original spec file:
  - Remove the seasonal//yyyy.mm/ and the save=rmx lines. Return all options back to the original.
  - Read in the regression matrix saved in the previous step as user-defined regressors:

```
regression{ …
        file = “MySeasonalRegressionFile.rmx” format = x13save
        user = (jan feb mar apr may jun jul aug sep oct nov)
        usertype = seasonal
}
```

  - Identifying the usertype as seasonal will apply the regressors directly to the seasonal factors

Applying the change to the seasonal factors (SEATS)

- Run with the seasonal//yyyy.mm/ regressors.

Example: Mexico GDP
Spec file to create regressor file

```
regression{ variables = ( #td1coef easter[1] AO1995.1 LS1995.1 LS2009.1
        seasonal//2009.1/)  save=rmx  }
# outlier{ types = (AO LS) }
forecast{ maxlead = 20  #maxlead = 4
}
```

Run with output name QuarterlyCORSeas2009q1

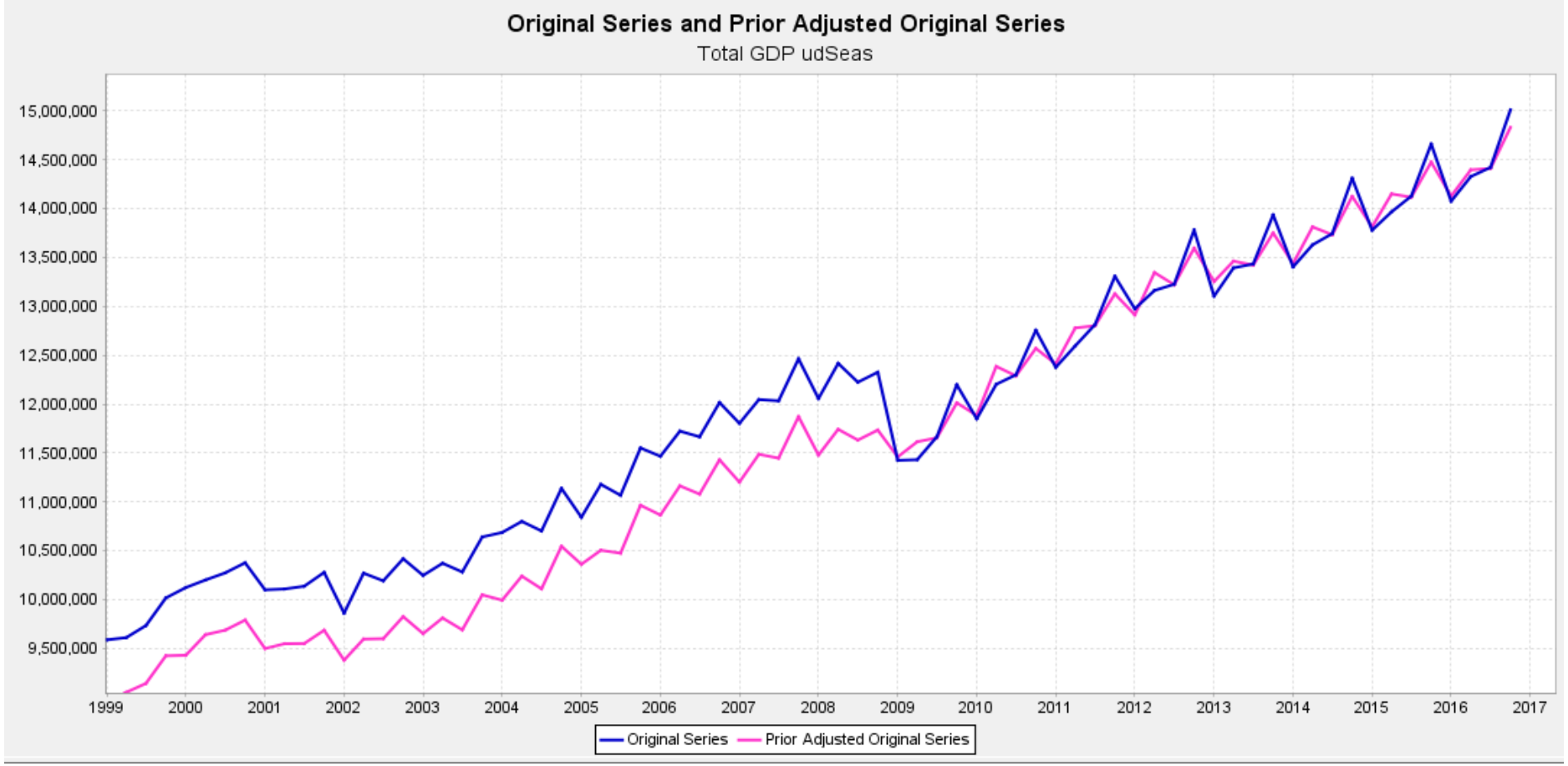
QuarterlyCORSeas2009q1.rmx

Date	1st II	2nd II	3rd II
199301	+0.000000000000000E+00	+0.000000000000000E+00	+0.000000000000000E+00
199302	+0.000000000000000E+00	+0.000000000000000E+00	+0.000000000000000E+00
199303	+0.000000000000000E+00	+0.000000000000000E+00	+0.000000000000000E+00
…			
200901	+0.100000000000000E+01	+0.000000000000000E+00	+0.000000000000000E+00
200902	+0.000000000000000E+00	+0.100000000000000E+01	+0.000000000000000E+00
200903	+0.000000000000000E+00	+0.000000000000000E+00	+0.100000000000000E+01
200904	-0.100000000000000E+01	-0.100000000000000E+01	-0.100000000000000E+01
201001	+0.100000000000000E+01	+0.000000000000000E+00	+0.000000000000000E+00
201002	+0.000000000000000E+00	+0.100000000000000E+01	+0.000000000000000E+00
201003	+0.000000000000000E+00	+0.000000000000000E+00	+0.100000000000000E+01
201004	-0.100000000000000E+01	-0.100000000000000E+01	-0.100000000000000E+01

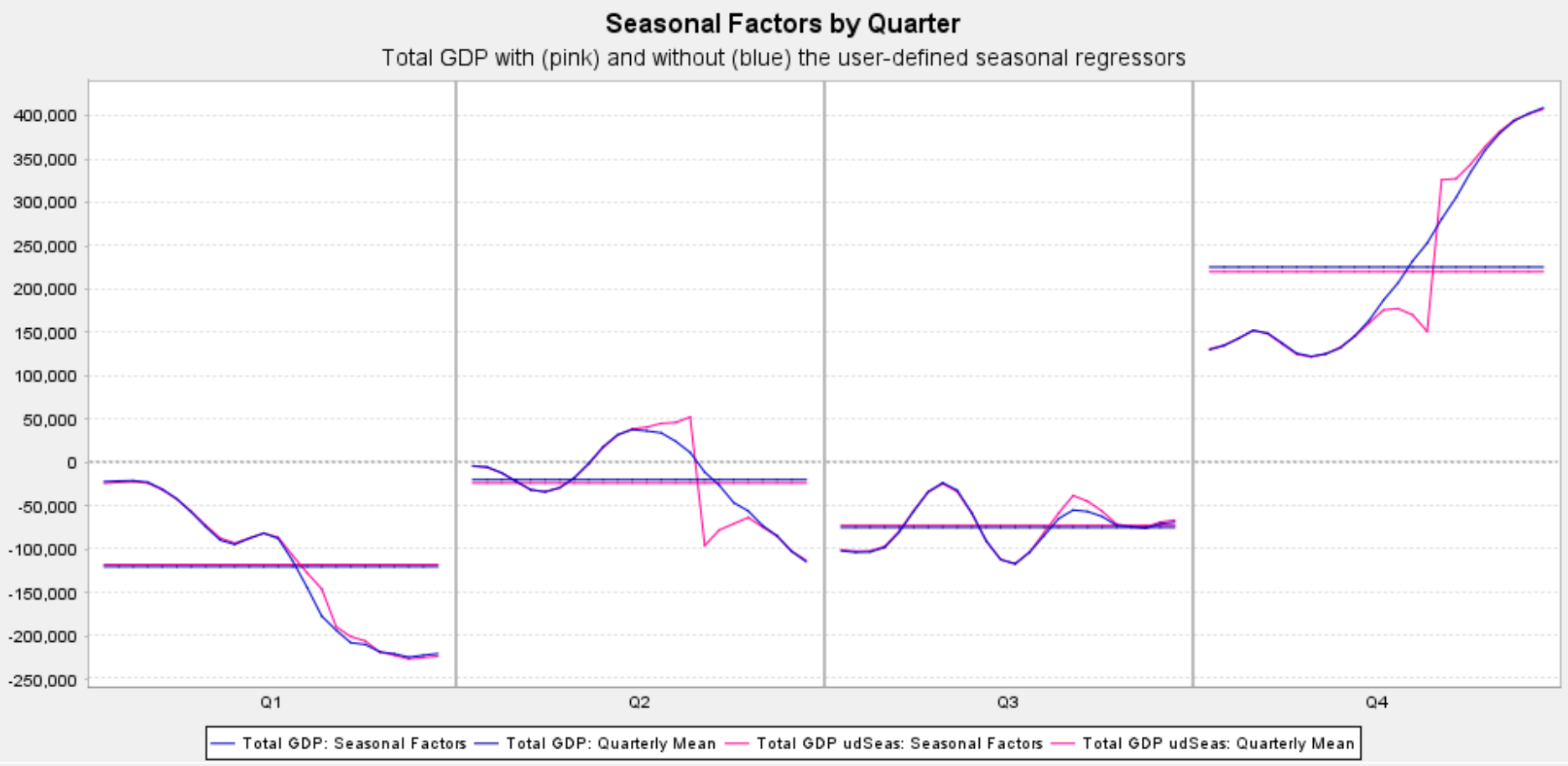
Example: Mexico GDP
Spec file to run with the user-defined regressors

```
regression{ variables = (td1coef easter[1] AO1995.1 LS1995.1 LS2009.1)
  file = “QuarterlyCORSeas2009q1.rmx” format=x13save
  user = (q1 q2 q3) usertype = seasonal }
outlier{ types = (AO LS) }
forecast{ maxlead = 4 }
arima{ model = (0 1 1)(0 1 1) }
x11{ seasonalma = s3x3 }
```

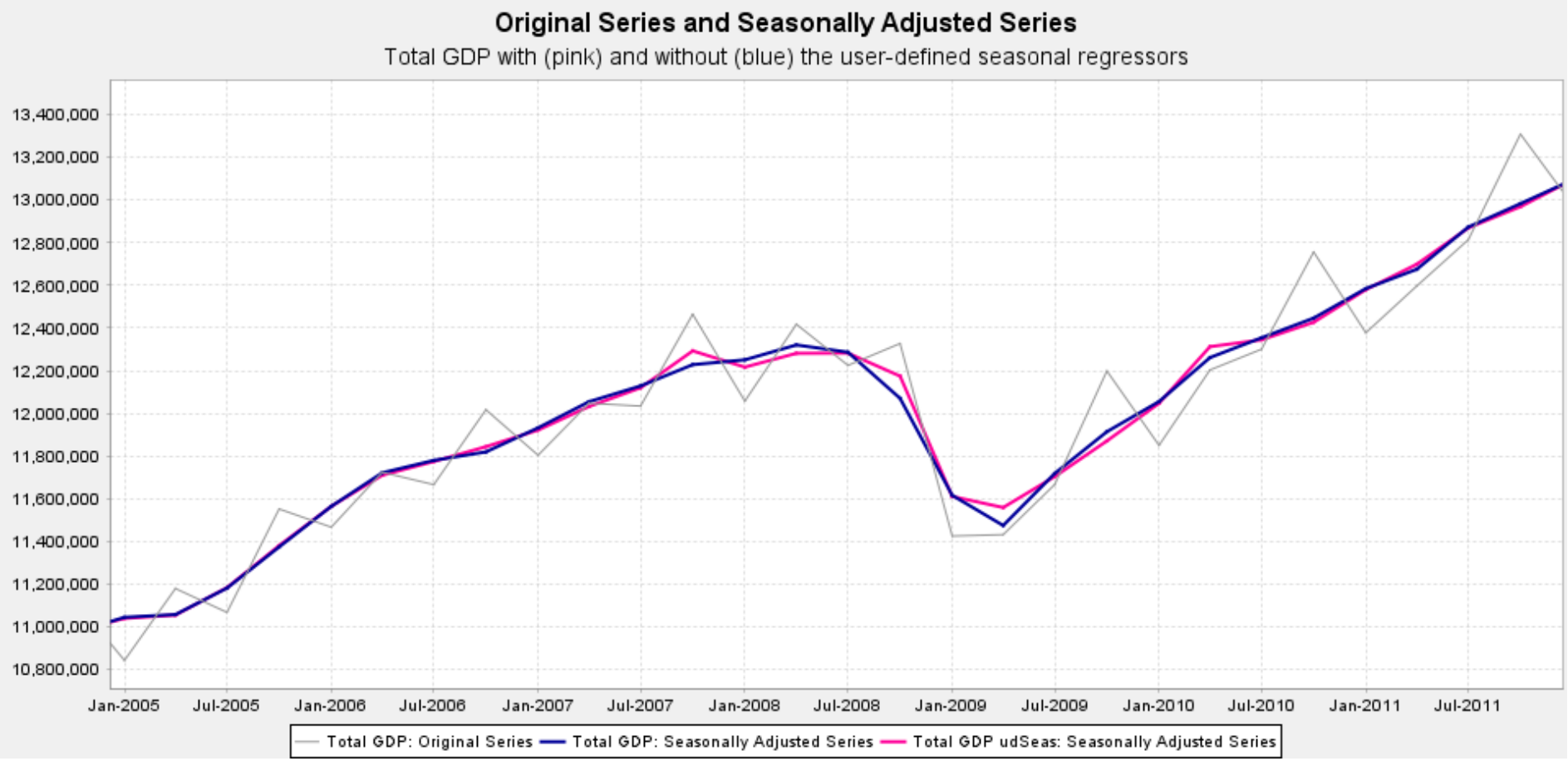
Example: Mexico GDP
Unadjusted series and prior adjusted series using the user-defined seasonal regressors



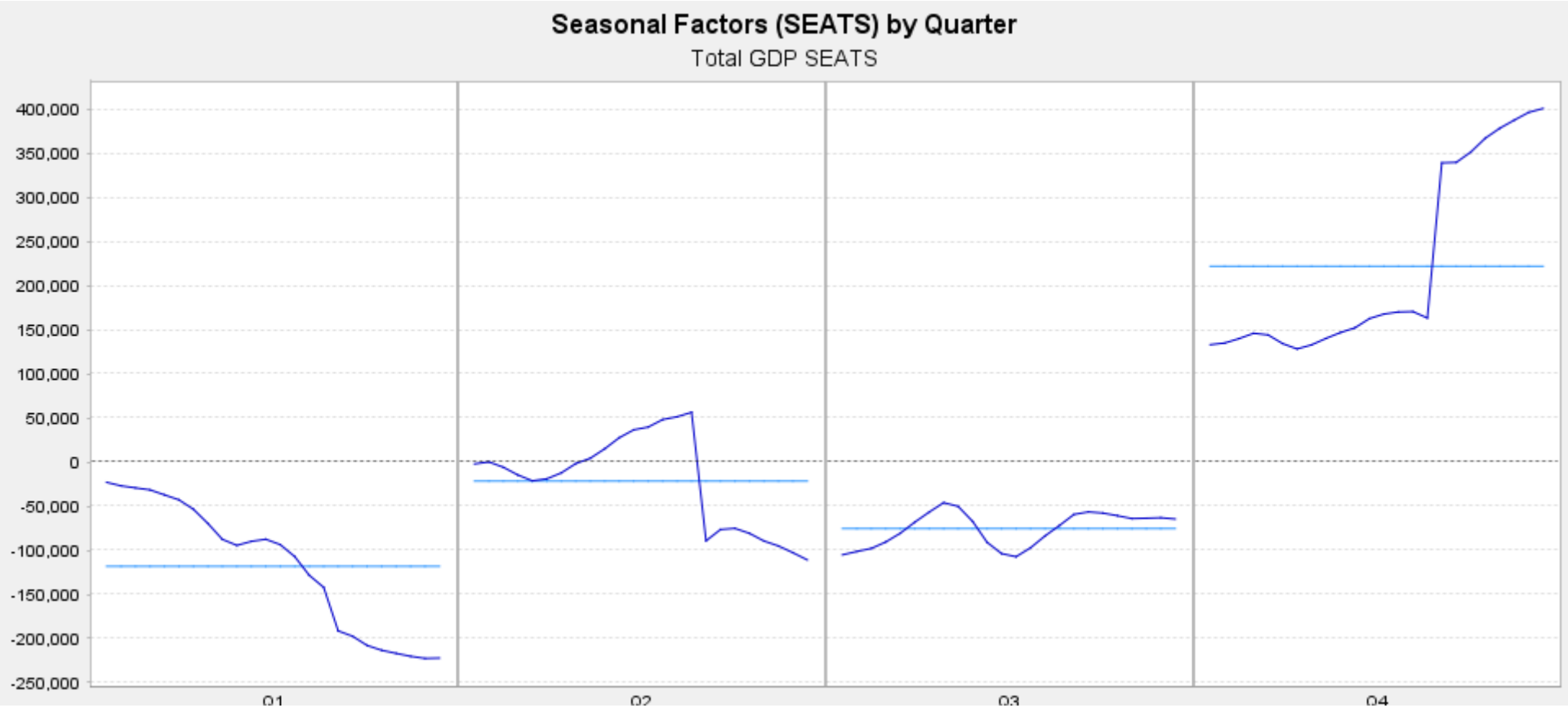
Example: Mexico GDP
Comparison of seasonal factors



Example: Mexico GDP
Comparison of seasonally adjusted series



Example: Mexico GDP
Seasonal factors when run with seasonal//2009.1/ and seats{}



Change-of-regime seasonal regressors vs. seasonal outlier

- X-13A-S has a built-in seasonal outlier, SOyyyy.mm, which similarly applies a sudden seasonal break to the seasonal factors, but only for one month
  - The other months are shifted a little to compensate

- The regressor is 0 for points on or after yyyy.mm; -1 for all months mm before yyyy.mm; and 1/(s-1) otherwise

Change-of-regime seasonal regressors and the pandemic

- Two years of data is enough to check for the significance of the change-of-regime regressors, but be careful with all the outliers
  - If all values post-pandemic are AOs, the spec won't run
  - You could get different results if you add the change-of-regime seasonal regressors to a spec file with all the selected 2020-2022 outliers than if you remove those outliers and let X-13 select them

Thank you!

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