# A large-scale application of Stata's forecast suite: challenges and potential

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- These commands support the definition of an *econometric model:* a set of estimated equations and identities that can be solved for a set of *endogenous variables* as functions of the *exogenous variables*.
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- This provides a feature not generally available to Stata's time series estimators: the ability to produce true *dynamic forecasts* of a single equation or of multiple equations.
- In a dynamic forecast, values of endogenous variables computed in one period are plugged in to the prediction equation in the next period. When the equation contains one or more lagged dependent variables, it is said to be dynamic. A one-period dynamic forecast from that equation is identical to a static forecast, but beyond one period ahead, they differ.
- Although `arima`, `var`, `svar`, `arch` and `mgarch` have postestimation commands that implement dynamic forecasts, such forecasts could not easily be computed after `regress`, `ivregress`, `sureg`, `reg3`, etc.
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- Klein Model I contains a total of three estimated equations and four identities: seven endogenous variables, which are functions of four exogenous variables.
- While useful as a textbook exercise, implementing this model does not illuminate the challenges faced when the `forecast` tools are used for a professional forecasting model of the US macroeconomy.
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# Modeling the macroeconomy for CCAR scenarios

- In the aftermath of the financial crisis, the Dodd–Frank legislation imposed new requirements on the Federal Reserve System's scrutiny of the largest financial institutions.
- The Fed has implemented the "CCAR" (Comprehensive Capital Analysis and Review) process for the 30+ largest financial institutions, involving "stress tests" of their modeled performance under various scenarios for macroeconomic variables that will affect their balance sheet and income statement.
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- CFG now produces macroeconomic forecasts and performs scenario analysis with an extended version of Prof. Ray Fair's highly respected model of the US macroeconomy.
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- The Fair US Model is a medium-size model of the macroeconomy, with about 30 estimated equations and a number of identities.
- The model captures the behavior of six sectors of the economy: households, nonfinancial firms, financial firms, the federal government, state and local governments and the foreign sector.
- The model explicitly considers the flow of funds among these sectors and balance sheet constraints, linking the US National Income and Product Accounts (NIPA) with the US Flow of Funds Accounts (FOF).
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To gain perspective on how this *medium-sized* econometric model differs from the textbook Klein Model I (3 equations, 7 endogenous variables, 4 exogenous variables), consider that our enhanced version of the Fair US model contains:

- 35 estimation results from `ivregress, regress, arima`
- plus 265 identities
- for a total of 300 endogenous variables
- as functions of 148 exogenous variables

We now describe how the model is employed in CFG's modeling efforts.

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- For instance, the altered path of real GDP growth under the Fed's Baseline, Adverse and Severe Adverse scenarios will cause all components of GDP to follow different paths during the forecast period than in the original model's dynamic forecasts.
- This is very easily implemented by the `actuals` option of `forecast solve`, which causes any non-missing values of endogenous variables to be held fixed in the solution process.
- Our first attempt to impose CCAR scenarios was not successful, as we tried to use `forecast adjust` to specify paths for endogenous variables which are defined by identities. Recent updates to the documentation state that this cannot be done: only estimated endogenous variables may be modified by `forecast adjust`.

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# In-sample backtests

- Analysis of the individual CFG custom equations (for brevity, not listed here) shows that they fit well over the estimation sample. We now consider their performance after integration with the full Fair US Model using a *backtest*.
- We construct a dynamic simulation of the model's 300 variables for the last 28 quarters of the estimation sample: 2008Q1–2014Q4.
- The model's fitted values over the simulation period are based on the model's own prior values, rather than the observed historical values.

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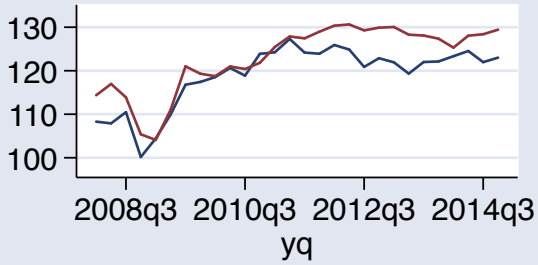
# Backtest: CFG Variables and Dynamic Forecasts

blue: actual, red: forecast)

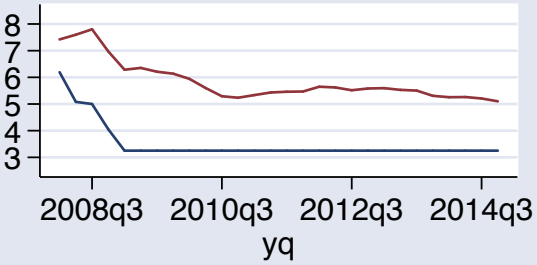
ALTSALES


MANHEIM

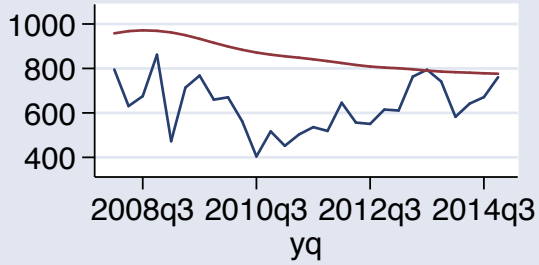



CREI

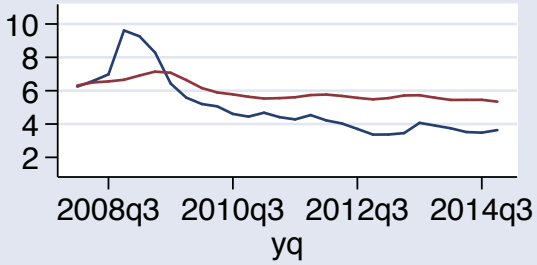

FRPRIME



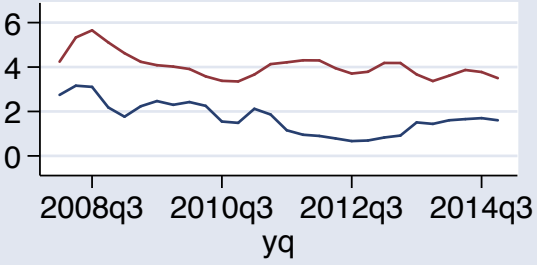

MORTORIG




RBBB




GS5




GS10


CORPPFT

- By starting the backtest in 2008Q1, we do not condition on the historical trajectories of macroeconomic variables during the financial crisis.
- Accordingly, the model does not capture the sharp drops in auto sales (ALTSALES) and mortgage originations (MORTORIG) caused by consumer credit constraints, nor the actual trajectory of interest rates (FRPRIME, RBBB, GS5, GS10) following unprecedented Fed actions.
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# Computing unconstrained dynamic forecasts

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- Dynamic forecasts over the 2015Q1–2017Q4 period produce trajectories for the model's 300 variables that are functions of exogenous variables' values and the model's logic.
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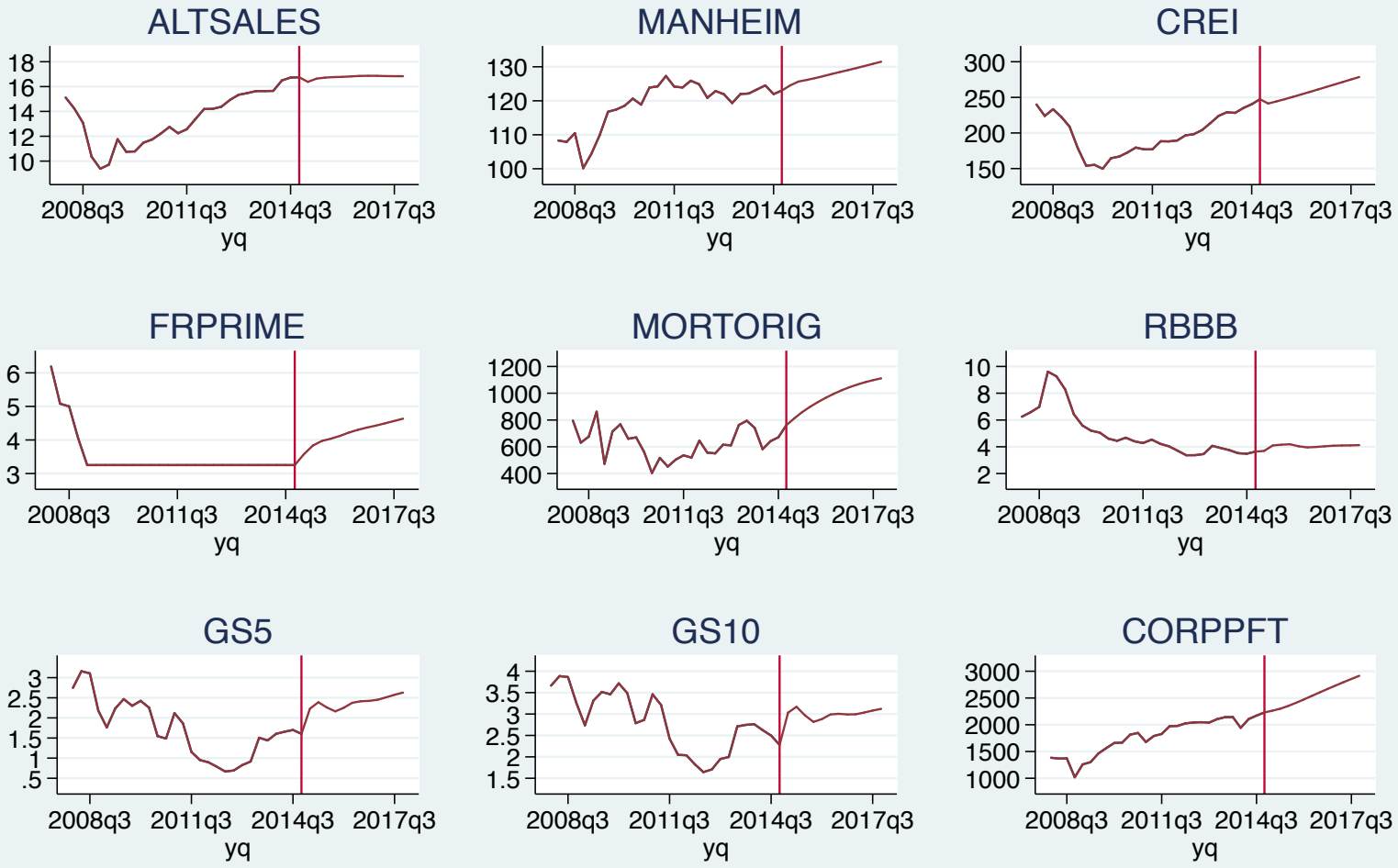


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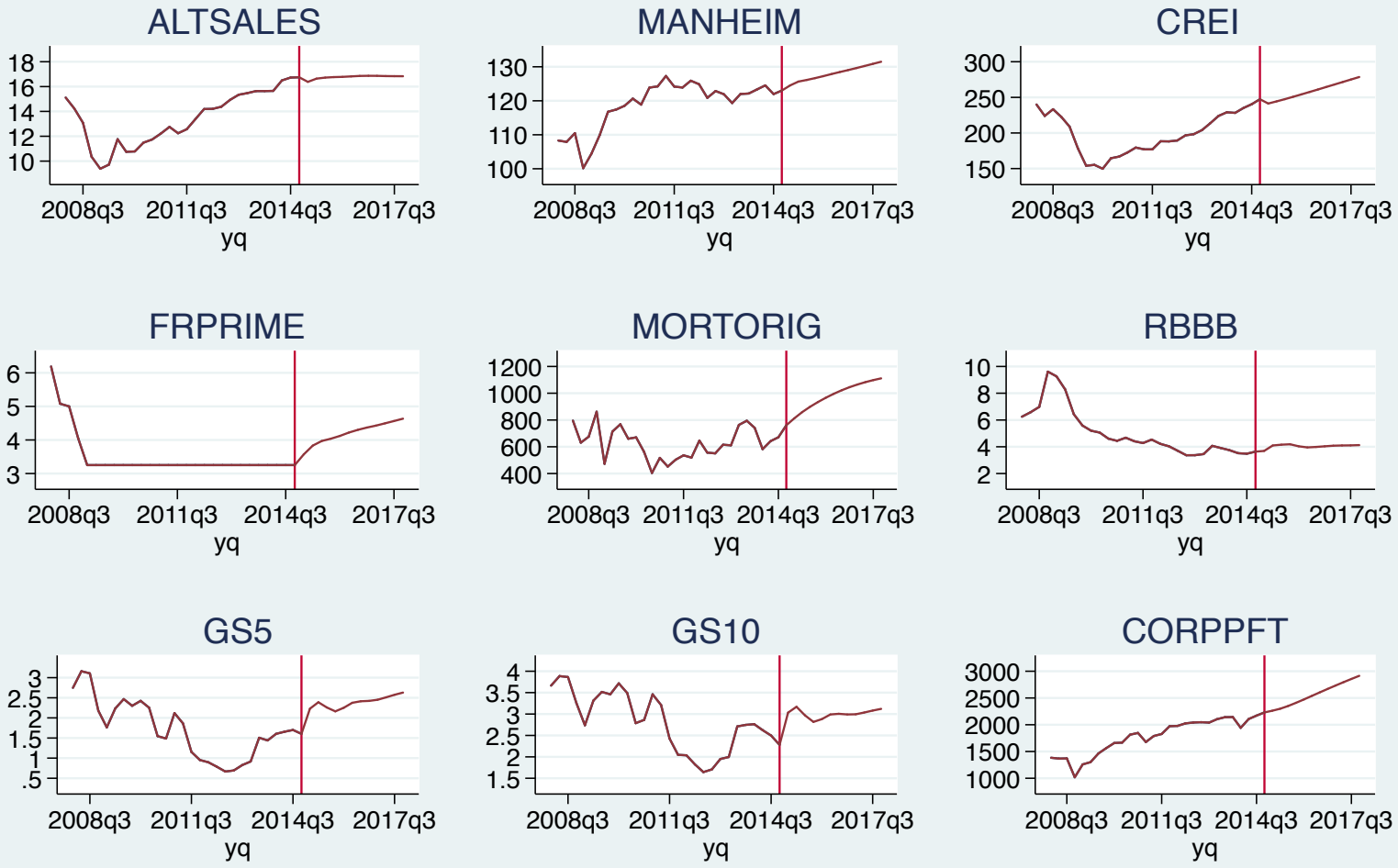


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- To implement the CCAR scenarios, we define the trajectories of several of the model's variables as those defined in each of the specified scenarios. These include:
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  - Percentage change, GDP Deflator
  - Real Disposable Income growth
  - Unemployment rate
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- Percentage change, GDP Deflator
- Real Disposable Income growth
- Unemployment rate
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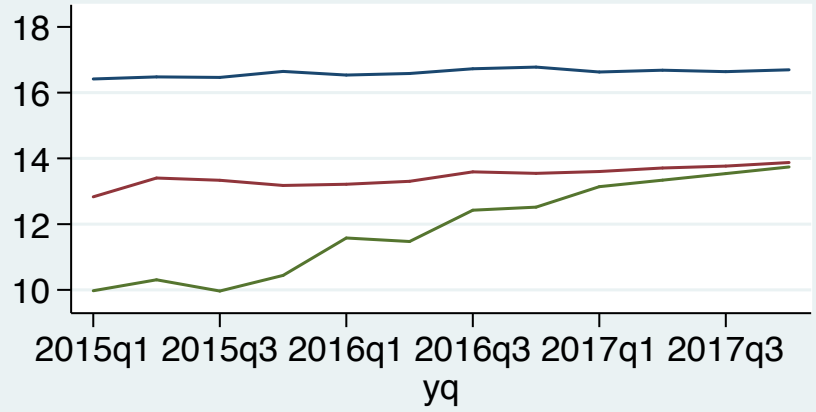
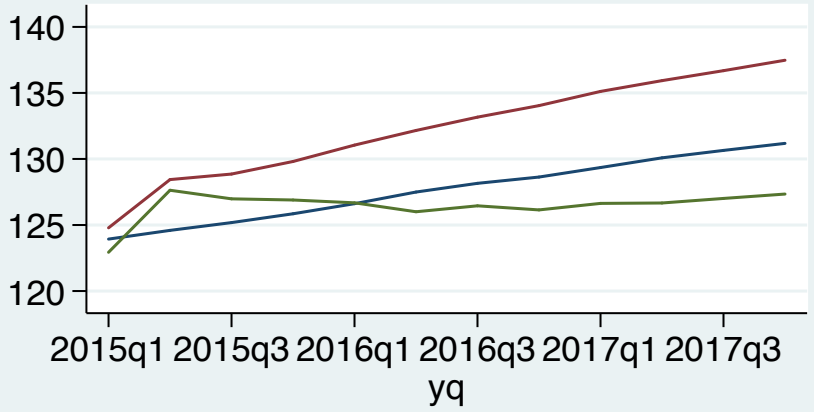
# CFG Variables under CCAR Scenarios

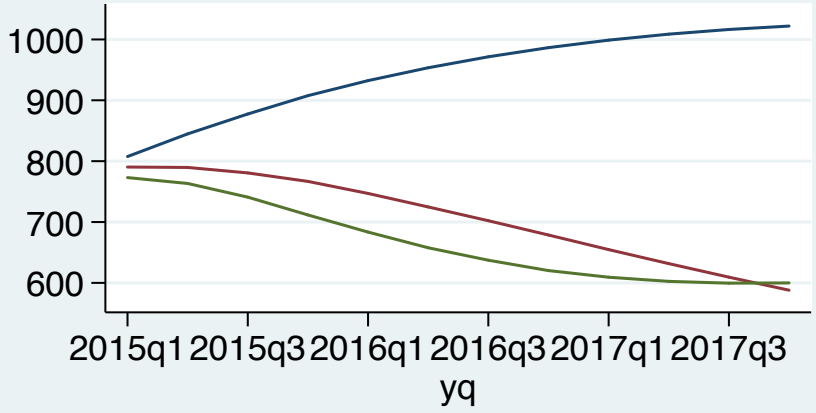
## Forecast: Light Vehicle Sales



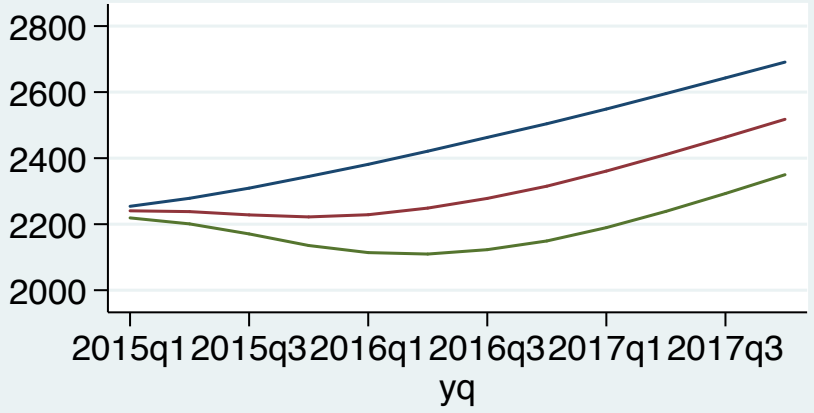

## Forecast: Used Car Price Index




## Forecast: Mortgage Originations




## Forecast: Corporate Profits




baseline adverse sev adverse

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- This illustrates how the macroeconomic modeling capabilities required for CCAR purposes and general risk management may be developed in-house, reducing reliance on 'black box' third-party forecasts subject to regulators' critiques.

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- First, it took many hours of head-scratching and debugging to get to this point.
- As the Stata manual indicates, all exogenous variables must be non-missing for the periods in which `forecast solve` is to be used.
- Declaration of exogenous variables is optional, but strongly encouraged.
- However, if a variable that appears in an exogenous role in any equation is not declared as such and is missing, the model will not solve, and the resulting error specifies that dozens—or hundreds—of endogenous variables cannot be computed: it does not spell out where the missing values appear.

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- In a toy model like Klein Model I, finding such a problem is trivial. In a realistic sized model, it is exceedingly difficult to track down the missing values.
- Obviously Stata is aware of the structure of each equation and identity, and should be able to track down problems of missing values in any exogenous variable. At present, it does not do so.
- I would recommend that Stata's `forecast describe exogenous` should be enhanced to include all exogenous variables, classifying them as defined and undefined. This would greatly enhance users' ability to debug their model.
- Attempts to use `forecast solve` for periods in which there are missing values should clearly specify the *exogenous* variable(s) in which missing values appear, rather than indicating all the *endogenous* variables for which solutions cannot be produced.

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- Second, in a model of this size, many similar variable names appear. Other econometric modeling software allows you to choose a variable and get a listing of what it depends upon (if endogenous) and what variables depend on it, highlighting everywhere in the model where this variable enters.
- This is a very useful feature, particularly if an endogenous variable is taking on unreasonable values in a dynamic simulation.
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- Although most of the information needed to rebuild the model can be saved to r-class macros by `forecast describe`, there is no command to save the model in a reusable form.
- The estimated equations can be saved to disk, as `.ster` files, so that reestimation is not required, but all of the `forecast...` commands defining the model must be given anew every time the model is to be used in a Stata session. These commands may be saved to a do-file with `forecast list`, but that do-file must be run to rebuild the model.
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- *SPEED:* solving the enhanced Fair model, 300 variables for each of 28 periods, takes only 21 seconds on a reasonably powerful (2.3 Ghz) laptop.
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