Implications of Recent U.S. Energy Trends for Trade Forecasts

By Craig S. Hakkio and Jun Nie

International trade is a growing share of economic activity in the United States and a determinant of economic growth. Over the last three decades, exports and imports have more than doubled as a share of gross domestic product. Moreover, the contribution of net exports to economic growth has also increased from a small drag from 2002 to 2005 to a positive contributor from 2006 to the end of 2013. Energy net exports were a substantial part of this change, as their contribution to annual real GDP growth increased from -0.1 percentage point (a drag) to 0.2 percentage point in the same periods.

Over the last two decades, two new technologies—hydraulic fracturing and horizontal drilling—brought significant structural change to the energy sector. After declining or holding steady from 1975 to 2005, energy production—including crude oil, natural gas, and natural gas liquids—increased starting in 2006. Partly as a result, net energy imports as a share of energy consumption fell by about half from 2005 to 2013 after having risen five-fold from 1960 to 2005.

Future policy changes could bolster these effects. The Energy Policy and Conservation Act of 1975 (EPCA) banned the export of most crude oil in an attempt to insulate the United States from worldwide price shocks. If this ban is lifted as some expect, however, the recent

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Craig S. Hakkio is a senior vice president and special advisor on economic policy at the Federal Reserve Bank of Kansas City. Jun Nie is a senior economist at the bank. This article is on the bank's website at ***www.KansasCityFed.org.***

changes in energy technology may have even larger effects on energy exports and thus overall exports.

This article examines how changes in energy production—and the resulting effects on U.S. energy imports and exports—affect trade forecasts. Exports and imports are typically determined by variations in foreign growth and domestic demand, respectively. Energy imports and exports, however, are mainly driven by technological improvements in crude oil and natural gas production. Consequently, distinguishing energy from non-energy components of trade may be useful in forecasting import and export growth, especially if forecasters want to know the effect of future energy production on the trade forecast.

Results from a model separating these components suggest U.S. energy imports will continue to decline while U.S. energy exports increase. However, the growth of energy imports and exports will differ from that of non-energy imports and exports. For example, real energy imports are expected to decline in 2014 and 2015, while real non-energy imports are expected to increase. The analysis also suggests slightly higher future energy production could lead to a significant drop in future energy imports. Finally, the analysis predicts net energy imports will decline 40 percent in 2014 and 2015, reducing the current aggregate real trade deficit by about 14 percent.

Section I reviews three decades of trends in energy production, consumption, and net imports. Section II estimates models for export and import growth, separating energy and non-energy components. Section III uses the estimated models to forecast imports and exports and to consider the effect of even faster growth in domestic energy production.

I. TRENDS IN CRUDE OIL AND NATURAL GAS PRODUCTION AND CONSUMPTION

Hydraulic fracturing, or "fracking," and horizontal drilling have had a significant effect on energy production. Although shale holds large amounts of natural gas, this gas had been difficult to extract before fracking was introduced. Fracking shoots water, chemicals, and sand into wells, creating fissures in the rock formations and thereby freeing the trapped gas. Fracking was developed in the 1940s, but the Mitchell Energy & Development Corporation made the first investment in large-scale hydraulic recovery in the 1980s.[1] At the same time, the Devon Energy Corporation was developing horizontal drilling techniques. With this technology, energy producers first drill down and then drill at an angle or even sideways. In this way, more of the reservoir is available and more gas can be recovered. Devon acquired Mitchell Energy in 2002 and combined fracking and horizontal drilling in 2003. The combination of these two technologies led to a significant structural change in energy production.

The effect of this structural change can be seen in several ways. Chart 1 shows U.S. energy production from 1960 to 2013, with a vertical line at 2006 to mark when energy production turned a corner. Production of natural gas and natural gas liquids reached historical highs in 2013, while petroleum production was about 25 percent below its 1970 historical high and closer to its 1990 level. Petroleum production has experienced wide swings: production increased until 1970, largely decreased until 2006, then increased through 2013. Natural gas has experienced wide swings as well, but with different timing: production increased until 1971, decreased until about 1986, then increased through 2013. Production of natural gas liquids has remained limited, with little trend up or down.

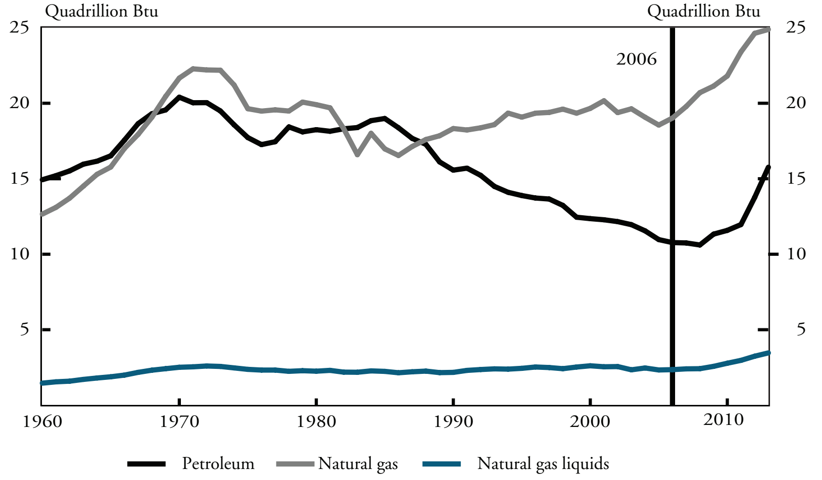
As energy production increased after 2006, net imports dropped significantly. Chart 2 shows that from the early 1980s through 2005, consumption of crude oil, natural gas liquids, and natural gas grew while production declined, leading to a significant increase in net imports. However, this trend reversed after 2006: consumption held relatively flat while production increased, leading to a significant decline in net imports. For example, after net imports peaked in 2005 at 31 quadrillion Btu, they declined in 2013 to 17.6 quadrillion Btu. The relatively flat path of energy consumption and fast growth of energy production since 2006 highlight the significance of energy production in shaping recent changes in net energy imports.

Energy Information Administration (EIA) forecasts illustrate the changes in energy trade by showing net imports of energy as a share of energy consumption from 1960 to 2040.[2] As shown in Chart 3, this share peaked in 2005 at 30 percent. By 2013, it had fallen to 13 percent, and is projected to fall further to 6.1 percent in 2020 and 3.3 percent in 2035 before increasing to 3.9 percent in 2040.

It has taken time to fully appreciate the past decade's technological improvements, and EIA production forecasts have been at times too

Chart 1

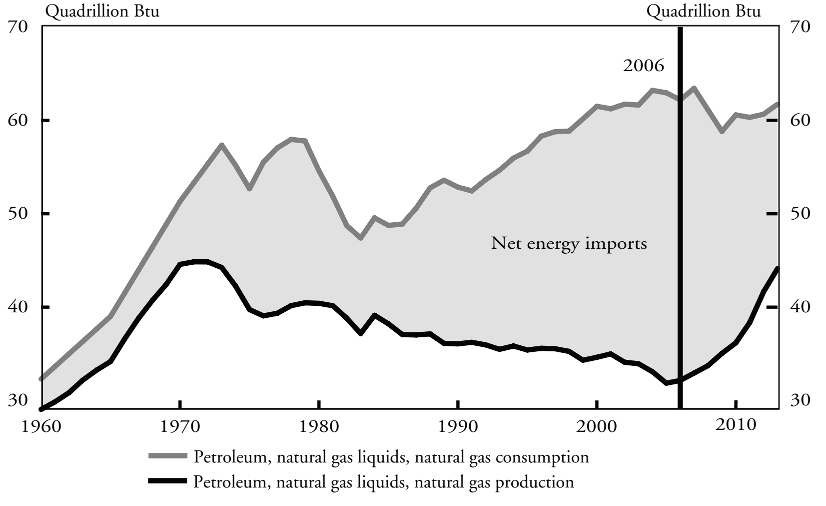
U.S. ENERGY PRODUCTION



Note: The British thermal unit (Btu) is the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit.
Sources: Energy Information Administration and Haver Analytics.

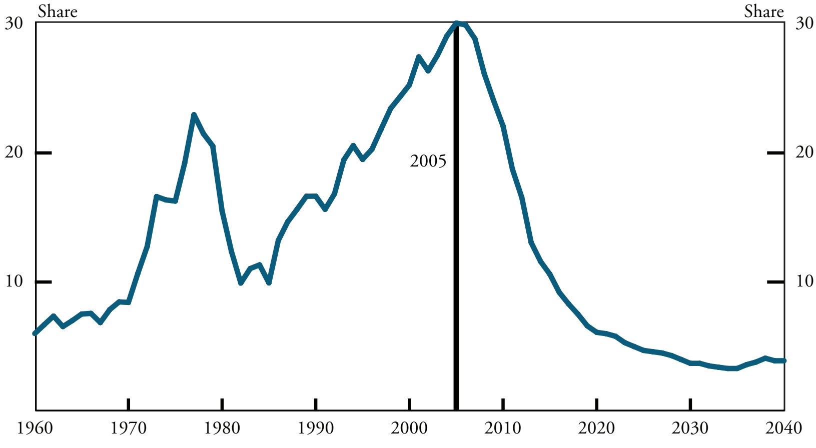
Chart 2

U.S. PRODUCTION, CONSUMPTION, AND IMPORTS OF PETROLEUM AND NATURAL GAS



Notes: Consumption data were available for 1960, 1965, 1970, 1973, 1974. Missing observations were linearly interpolated. The British thermal unit (Btu) is the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit.
Sources: Energy Information Administration and Haver Analytics.

Chart 3
NET ENERGY IMPORTS AS A SHARE OF ENERGY CONSUMPTION



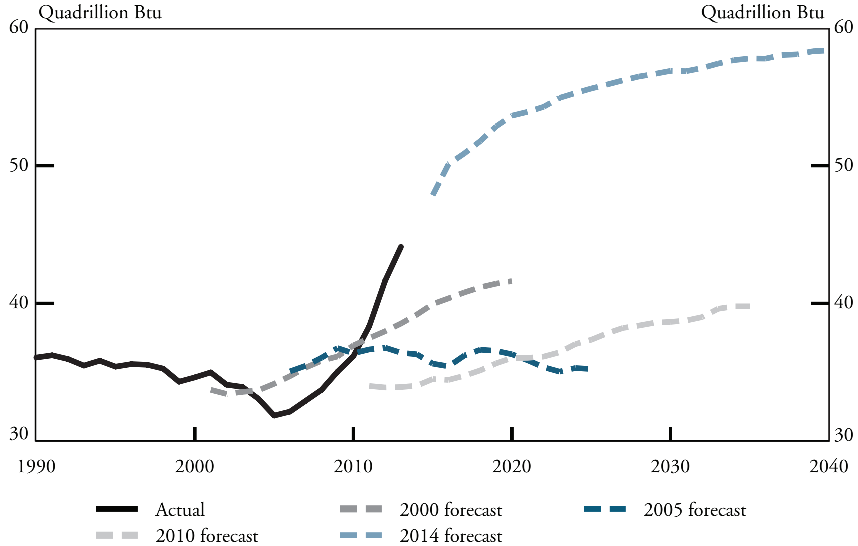
Sources: Energy Information Administration and Haver Analytics.

conservative. Chart 4 compares EIA forecasts for crude oil and lease condensate, natural gas plant liquids, and dry natural gas to actual production.[3] The dashed lines show projections made in 2000, 2005, 2010, and 2014, while the solid black line shows actual energy production. EIA projections have generally called for some increase in energy production over the forecast horizon, but some reports have underestimated the magnitude of this increase. For example, the production forecasts for 2020 in reports from 2000, 2005, and 2010 were generally about 35 to 40 quadrillion Btu. In the 2014 report, however, the forecast for 2020 was 54 quadrillion Btu. More specifically, from the 2010 to 2014 reports, the forecast for energy production in 2020 increased almost 50 percent.

Forecasts of U.S. net imports of petroleum and natural gas changed comparably. Chart 5 is similar to Chart 4 in that it shows actual net imports of petroleum and natural gas alongside EIA forecasts made in 2000, 2005, 2010, and 2014.[4] From 1990 to 2005, net imports increased, and EIA forecasts suggested those increases were likely to continue. However, net imports began to decline in 2006, falling from 31 quadrillion Btu in 2005 to 18 quadrillion Btu in 2013 (solid black line). The EIA now projects net imports will continue to decline to 9 quadrillion Btu in 2040 (dashed light blue line).

Chart 4

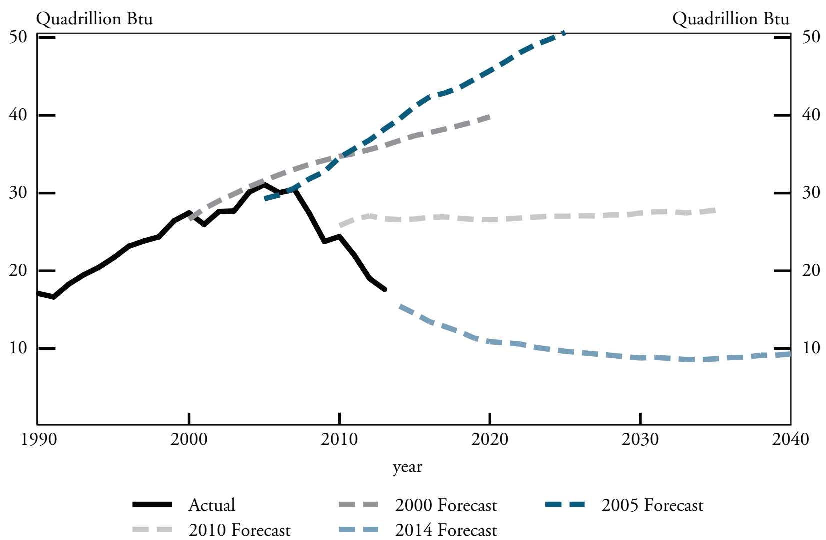
PRODUCTION OF CRUDE OIL, NATURAL GAS LIQUIDS, AND NATURAL GAS



Note: The British thermal unit (Btu) is the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit.
Source: Energy Information Administration.

Chart 5

NET IMPORTS OF PETROLEUM AND NATURAL GAS



Source: Energy Information Administration.

To summarize, the technology for energy extraction changed significantly during the late 1990s and early 2000s, culminating in an average annual increase in energy production of 4.2 percent from 2006 to 2013. Net imports fell by half over the same period.[5] Structural changes in energy production have had clear and significant effects on energy imports and exports. As a result, any statistical model for these imports and exports intended to forecast energy imports and exports should begin the sample period in 2006 to account for these changes.

II. ESTIMATING ENERGY AND NON-ENERGY IMPORTS AND EXPORTS

Based on the results in the previous section, this section estimates several statistical models for the energy and non-energy components of imports and exports separately, starting in 2006. The estimation uses a vector autoregression (VAR) for the energy and non-energy components of imports and exports.[6] Appendix A provides more detailed information about how the variables were constructed.

Energy imports and exports both depend on the domestic production and relative price of energy. Energy imports also depend on domestic energy consumption, while energy exports depend on foreign energy consumption.[7] Non-energy imports and exports depend on the real exchange rate and a measure of overall demand. For non-energy imports, overall demand by the U.S. is measured by real personal consumption expenditures plus real business fixed investment; for non-energy exports, overall demand by foreign countries is measured by real GDP.

The estimated models allow for general dynamic interaction among all variables by allowing each variable to depend on past values of all variables. All variables are measured as the growth rate from the previous quarter. Reflecting the structural change in energy production, equations for energy imports and exports are estimated using data beginning in the first quarter of 2006. Equations for non-energy imports and exports use data beginning in the second quarter of 2002. Appendix B provides a more detailed description of the model equations.

Since the parameters of a VAR can be difficult to interpret, this section follows standard procedures and plots the cumulative orthogonalized impulse response function. The impulse response function traces the effect of a shock in one variable on the future path of all variables in the model. However, the resulting estimates cannot be interpreted structurally because the shocks to all variables are correlated—in other words, if one variable is shocked, all the variables will be shocked. Therefore, without additional structure, the effect of a shock in only one variable cannot be traced out.

The common solution to this problem is to calculate the orthogonalized impulse response function. In this case, a structure is imposed on the model so that the shocks are now orthogonal—that is, uncorrelated—and one variable can be shocked without all other variables being simultaneously shocked. As a result, the effect of a shock to one variable on the path of all other variables can be determined.

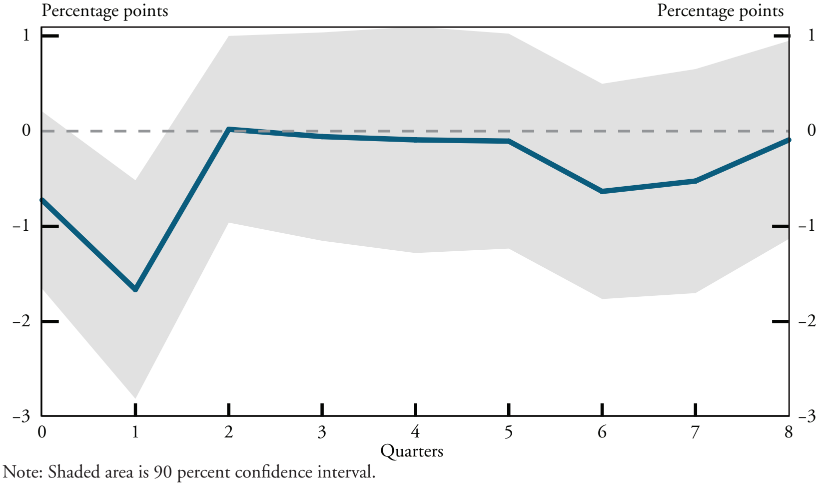
To see the overall effect of a shock to growth in energy production on growth of energy imports and exports over the forecast horizon, the cumulative orthogonalized impulse response function is shown in Charts 6 and 7.

This experiment has two key findings regarding increases in domestic energy production. First, an increase in domestic energy production leads to a reduction in energy imports (Chart 6). Specifically, if the growth rate of domestic energy production increases by 1 percentage point, the energy import growth rate declines by 1.7 percentage points over the current and next quarters—a statistically significant effect. Similarly, a 1-percentage-point increase in domestic energy production growth leads to a 1-percentage-point increase in export growth over the current and next quarters. This effect, however, is statistically insignificant (Chart 7).[8]

That an increase in domestic energy production has different effects on near-term energy imports and exports is perhaps unsurprising. Imports may simply respond to a change in energy production before exports, as changes in exports require new distributors in foreign countries. The ban on U.S. crude oil exports enacted in the EPCA might also explain these disparate effects.[9] If the United States lifts the ban, it may take time for domestic energy producers to break into foreign markets. Nevertheless, continued growth in U.S. energy production would be expected to lead to new foreign markets and increased energy exports.[10]

Chart 6

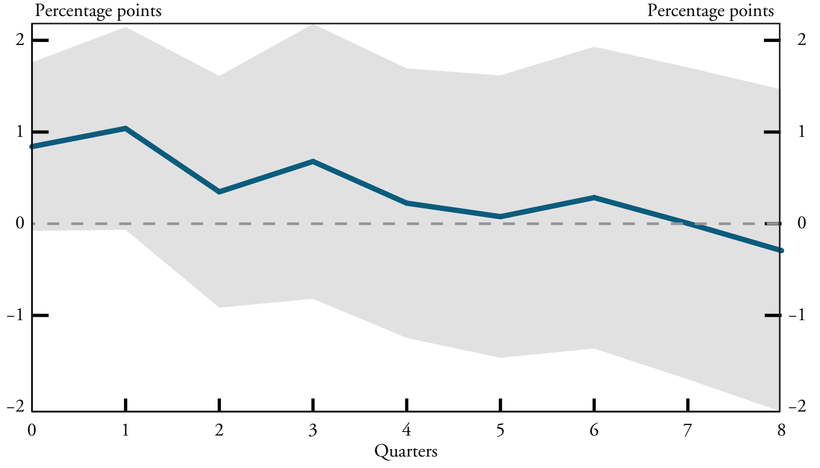
CUMULATIVE RESPONSE OF GROWTH IN ENERGY IMPORTS FROM A 1-PERCENTAGE-POINT INCREASE IN DOMESTIC ENERGY PRODUCTION



Note: Shaded area is 90 percent confidence interval.
Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Census Bureau, Federal Reserve Board, Energy Information Administration, Haver Analytics, and authors' calculations.

Chart 7

CUMULATIVE RESPONSE OF GROWTH IN ENERGY EXPORTS FROM A 1-PERCENTAGE-POINT INCREASE IN DOMESTIC ENERGY PRODUCTION



Note: Shaded area is 90 percent confidence interval.
Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Census Bureau, Federal Reserve Board, Energy Information Information, Haver Analytics, and authors' calculations.

III. IMPLICATIONS FOR TRADE FORECASTS

The model developed in the previous section can be used to generate both unconditional and conditional forecasts for international trade—energy and non-energy imports and exports—over the next two years. In an unconditional forecast, the estimated model forecasts all variables without imposing any assumptions on their future paths.[11] In a conditional forecast, additional outside information is incorporated into the model. For example, since forecasts for energy production have consistently been revised up over the last decade, the model can forecast imports and exports assuming even higher future energy production than in the unconditional forecast. In this way, the model can be used to analyze the implications of even faster growth in energy production.

Unconditional growth forecasts of imports and exports

The model generates unconditional forecasts using no outside information on future paths of key variables. Specifically, the model treats all variables symmetrically and provides forecasts for the growth of imports, exports, domestic and foreign energy consumption, domestic energy production, and relative prices based on historical relationships and dynamics estimated in the previous section.

Based on these historical relationships and recent trends, the model predicts the future paths of energy import and export growth will be very different from those of non-energy import and export growth. Energy imports are projected to decline 2.9 percent in 2014 and 4.6 percent in 2015 (Table 1, columns 1 and 4). The average pace in 2014 and 2015 is in line with the 3.7 percent average annual decline observed in the last four years. In contrast, non-energy imports are projected to grow 7.2 percent in 2014 and 4.5 percent in 2015 (Table 1, columns 2 and 5). These results are consistent with continued strong growth in energy production leading to a continued decline in energy imports, while continued strong growth in domestic demand leads to an increase in non-energy imports.[12]

The unconditional forecast for exports shows energy exports are expected to increase 12.3 percent in 2014 and 19.4 percent in 2015 (Table 1, columns 1 and 4), much larger than the respective 4.2 percent and 4.1 percent growth rates for non-energy exports. The expected

Table 1
FORECASTS OF IMPORTS AND EXPORTS

	2014 Q4/Q4			2015 Q4/Q4		
	Unconditional (percent)	Conditional (percent)	Difference (percentage points)	Unconditional (percent)	Conditional (percent)	Difference (percentage points)
Imports						
Energy	-2.9	-5.5	-2.6	-4.6	-5.9	-1.3
Non-energy	7.2	7.2	0.0	4.5	4.5	0.0
Total	6.3	6.0	-0.3	3.7	3.7	0.0
Exports						
Energy	12.3	17.1	4.8	19.4	18.4	-1.0
Non-energy	4.2	4.2	0.0	4.1	4.1	0.0
Total	4.6	4.9	0.3	4.9	4.9	0.0

Note: The conditional forecast assumes a 1-percentage-point increase in domestic energy production in each quarter of 2014-15.
Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Census Bureau, Energy Information Administration, Federal Reserve Board, Haver Analytics, and authors' calculations.

growth in energy exports is consistent with the average pace of 15.2 percent over the last four years.

When combining energy and non-energy forecasts, total real U.S. imports are projected to grow 6.3 percent in 2014 and 3.7 percent in 2015. The increased growth in 2014 reflects a larger increase in non-energy imports and a smaller decline in energy imports than in 2015. Total real exports are projected to grow at a more consistent rate in 2014 and 2015, though energy export growth is expected to be significantly stronger in 2015.[13]

Conditional growth forecasts of imports and exports

Since it is difficult to accurately forecast energy production and net imports, a conditional forecast shows the effect of energy production 1 percentage point higher in each quarter than in the unconditional forecast. The model treats energy production as an endogenous variable that is affected by other variables in the model. This means a 1-percentage-point increase in the growth of energy production cannot simply be assumed without specifying its cause. For this simulation, the driving force is a shock to energy production alone, rather than to any other variables. The simulation method thus imposes a sequence of shocks to energy production consistent with energy production increasing 1 percentage point in each quarter of 2014 and 2015, then allows those shocks to affect all variables in the model.[14]

The simulation has two key findings for energy import and export forecasts. Table 1 compares the results of the unconditional and conditional forecasts. First, if energy production grows 1 percentage point more in each quarter of 2014 and 2015 than in the unconditional forecast, energy imports would fall about 2.6 percentage points and 1.3 percentage points more in 2014 and 2015, respectively, consistent with reduced need for energy imports (Table 1, columns 3 and 6). Second, energy exports would be expected to increase almost 5 percentage points more in 2014 and 4 percentage points more in 2015. Even though energy export growth in 2015 is lower than in the unconditional forecast, the implied level of energy exports would be about 3 percentage points to 4 percentage points higher.[15]

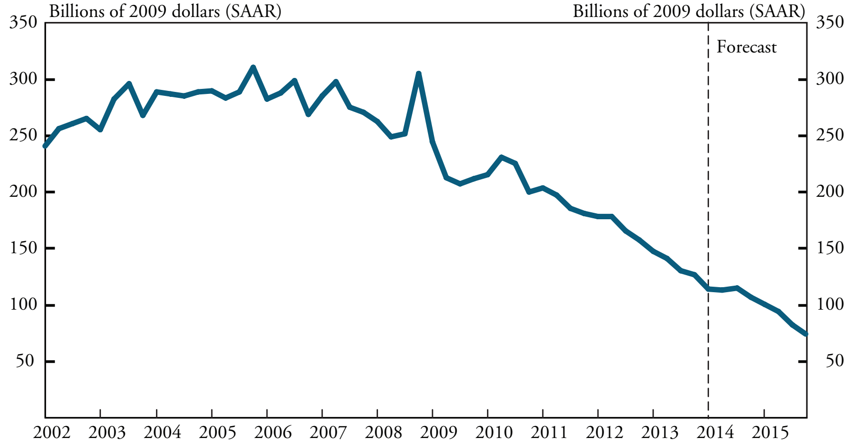
These changes in energy imports and exports lead to changes in total imports and exports. Total import growth in the conditional forecast is 0.3 percentage point lower in 2014 than in the unconditional forecast, but unchanged in 2015. Similarly, total export growth in the conditional forecast is 0.3 percentage point higher in 2014 but unchanged in 2015. The changes in overall imports and exports are relatively minor, as energy imports and exports are still comparatively small components of overall imports and exports.

Implications for the U.S. trade deficit

The real trade deficit, the difference between real imports and real exports, was $383 billion in the fourth quarter of 2013. Of that total, the real energy deficit made up one-third, or $127 billion (Chart 8). The VAR analysis suggests that energy imports are expected to decline and energy exports to increase in the near term, which should help significantly narrow the trade deficit. Based on the unconditional forecast, net energy imports are expected to decline $52.8 billion by the end of 2015, about 40 percent of current net energy imports. In addition, the analysis suggests both the decline in energy imports and the increase in energy exports will play an important role in reducing the future energy deficit.

However, this forecast assumes foreign demand for energy will continue to grow at its recent pace. If growth in foreign demand slows, for example, due to an economic slowdown in emerging economies, the

Chart 8
ENERGY TRADE DEFICITS



Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Census Bureau, Energy Information Administration, Federal Reserve Board, Haver Analytics, and authors' calculations.

future energy export growth rate could also decline. Similarly, significant increases in energy prices could slow future energy export growth.

To summarize, the above framework predicts a continued decline in U.S. energy imports and a fast increase in U.S. energy exports. Though the framework's prediction for future domestic energy production follows the EIA forecast, slightly higher future energy production could lead to a significantly larger drop in future energy imports. In addition, net energy imports are expected to continue to decline significantly, narrowing the U.S. trade deficit.

CONCLUSION

U.S. energy production has changed dramatically since 2006 due to technological advances in the energy industry. To better capture these recent changes and study their effects on future U.S. trade, this article proposes a model that separates the energy and non-energy components to forecast near-term imports and exports for both. In addition to providing an independent trade forecast, the framework is flexible and can generate alternative forecasts under additional assumptions of future domestic energy production.

The framework forecasts a 2.9-percent decline in energy imports in 2014 and a 4.6-percent decline in 2015. The key factors shaping this forecast include relatively stable domestic energy consumption and a continued increase in energy production, which reduces reliance on energy imports. Energy exports are expected to increase 12.3 percent in 2014 and 19.4 percent in 2015. The strong growth is supported by both a continued increase in domestic energy production and continued rising foreign demand. Combining the forecasts for imports and exports, net energy imports are expected to narrow by 40 percent, which helps reduce the current trade deficit by about 14 percent.

APPENDIX A
DATA DESCRIPTION

The analysis relies on data obtained from Haver Analytics. All variables included in the analysis are quarterly percent changes (not annualized).

The Bureau of Economic Analysis reports quarterly estimates of real imports and exports of goods and services, measured in billions of chained 2009 dollars at a seasonally adjusted annualized rate. The analysis refers to these variables as total imports and exports.

Quarterly real energy imports and exports include the traded goods in Harmonized System category 27—mineral fuels, mineral oils, and products of their distillation; bituminous substances; and mineral waxes. Monthly nominal values from the Census Bureau, summed over each quarter, are deflated by the category's corresponding monthly price index published by the Bureau of Labor Statistics and averaged over each quarter. Both the nominal values and price indexes are seasonally adjusted using Haver Analytics. The resulting real energy imports and exports series are measured in billions of chained 2009 dollars at a seasonally adjusted annualized rate.

Real non-energy imports are the chain-weighted sum of quarterly real imports of services and quarterly real imports of goods, both reported by the Bureau of Economic Analysis, less the previously described measure of quarterly real energy imports. Real non-energy exports are defined analogously. Non-energy imports and exports are both measured in billions of chained 2009 dollars at a seasonally adjusted annualized rate.

The real broad trade-weighted exchange value of the U.S. dollar is published by the Federal Reserve Board. The quarterly series is calculated as an average of the Board's monthly average series.

The relative energy price is defined as the ratio of the energy price index to the overall consumer price index. Each index is a quarterly average of monthly readings with base years 1982-84.

Domestic demand is represented by the chain-weighted sum of real personal consumption expenditures and real business fixed investment, each reported by the Bureau of Economic Analysis in billions of chained 2009 dollars at a seasonally adjusted annualized rate.

Foreign demand is measured by foreign real GDP growth, which is calculated as a weighted average of real GDP growth rates in 55 countries. These countries are listed in Table A1 along with their sources. Together, these 55 countries accounted for an average 87 percent of foreign GDP (world GDP excluding U.S. GDP) from 2005 to 2012. In constructing foreign real GDP growth, each country's growth rate is weighted by its share of nominal GDP in the sample.

The EIA produces data on domestic production and consumption of and international demand for energy products. Domestic production of energy products is the sum of crude oil production and natural gas production, both measured in quadrillion Btu. Domestic consumption includes consumption of petroleum (including natural gas liquids) and natural gas, measured in quadrillion Btu. Foreign consumption is defined as world petroleum demand less U.S. petroleum demand, measured in millions of barrels per day. Each of these series is seasonally adjusted using Haver Analytics.

Table A1
FOREIGN GDP SOURCES

Country	Sources
Argentina	Ministerio de Economía y Obras y Servicios Públicos, Haver Analytics
Australia	IMF
Austria	Austrian Institute of Economic Research, Statistik Austria, Haver Analytics
Belarus	IMF
Belgium	Banque Nationale de Belgique
Bolivia	Instituto Nacional de Estadísticas, Haver Analytics
Botswana	Central Statistical Office, Haver Analytics
Brazil	Instituto Brasileiro de Geografia e Estatística, Haver Analytics
Bulgaria	National Statistical Institute, Haver Analytics
Canada	Statistics Canada
Chile	IMF
China	China National Bureau of Statistics, Haver Analytics
Costa Rica	Banco Central de Costa Rica, Haver Analytics
Croatia	IMF
Cyprus	Statistical Service of the Republic of Cyprus
Czech Republic	Czech Statistical Office, IMF
Denmark	Danmarks Statistik
Estonia	Statistical Office of Estonia, IMF
Finland	Tilastokeskus
France	Institut National de la Statistique/Economique
Georgia	IMF, National Bank of Georgia, Haver Analytics
Germany	Deutsche Bundesbank
Hong Kong	Hong Kong Census and Statistics Department, Haver Analytics
Hungary	Central Statistical Office, Haver Analytics
Iceland	Statistics Iceland
India	Central Statistical Office of India, Haver Analytics
Indonesia	Biro Pusat Statistik, Haver Analytics
Ireland	Central Statistics Office Ireland
Israel	Central Bureau of Statistics, Haver Analytics
Italy	Istituto Nazionale di Statistica
Japan	Cabinet Office of Japan
Jordan	Department of Statistics, Haver Analytics
Korea	Bank of Korea, IMF
Latvia	Central Statistical Bureau of Latvia, Haver Analytics
Lithuania	Lithuania Department of Statistics, Haver Analytics
Luxembourg	Central Service of Statistics & Economic Studies
Malaysia	IMF

Table A1 Continued

Country	Sources
Mexico	Instituto Nacional de Estadística y Geografía, IMF
Netherlands	Centraal Bureau voor de Statistiek
New Zealand	IMF
Norway	Statistisk Sentralbyra
Paraguay	Banco Central del Paraguay, Haver Analytics
Peru	Banco Central de Reserva del Perú, Haver Analytics
Philippines	IMF
Poland	Central Statistical Office of Poland, Haver Analytics
Portugal	Instituto Nacional de Estatistica
Russia	Federal State Statistics Service, Haver Analytics
Singapore	Department of Statistics, Haver Analytics
South Africa	South African Reserve Bank, IMF
Spain	Instituto Nacional de Estadística
Sweden	Statistiska Centralbyran
Switzerland	State Secretariat for Economic Affairs
Thailand	National Economic and Social Development Board, Haver Analytics
Turkey	Turkish Statistical Institute, Haver Analytics
United Kingdom	Office for National Statistics

APPENDIX B
VAR MODELS

The vector autoregression (VAR) models used to estimate import growth and export growth have the following form:

$$y_t = A_0 + A_1 \cdot y_{t-1} + A_2 \cdot y_{t-2} + A_3 \cdot y_{t-3} + A_4 \cdot y_{t-4} + \in_t,$$

where y_t refers to the vector of variables included in each estimation.

For the estimation of energy import growth,

$$y_t = \begin{bmatrix} \text{Real Energy Import Growth}_t \\ \text{Domestic Energy Consumption Growth}_t \\ \text{Domestic Energy Production Growth}_t \\ \text{Relative Energy Price Growth}_t \end{bmatrix}$$

and A_i is a 4x1 vector for $i = 0$ and a 4x4 matrix for $i = \{1,2,3,4\}$.

Similarly, for the estimation of energy export growth,

$$y_t = \begin{bmatrix} \text{Real Energy Export Growth}_t \\ \text{Foreign Energy Consumption Growth}_t \\ \text{Domestic Energy Production Growth}_t \\ \text{Relative Energy Price Growth}_t \end{bmatrix}$$

and A_i is a 4x1 vector for $i = 0$ and a 4x4 matrix for $i = \{1,2,3,4\}$.

For the estimation of non-energy import growth,

$$y_t = \begin{bmatrix} \text{Real Non-energy Import Growth}_t \\ \text{Real Domestic Demand Growth}_t \\ \text{Real Exchange Rate Growth}_t \end{bmatrix}$$

and A_i is a 3x1 vector for $i = 0$ and a 3x3 matrix for $i = \{1,2,3,4\}$.

Similarly, for the estimation of non-energy export growth,

$$y_t = \begin{bmatrix} \text{Real Non-energy Export Growth}_t \\ \text{Real Foreign Demand Growth}_t \\ \text{Real Exchange Rate Growth}_t \end{bmatrix}$$

and A_i is a 3x1 vector for $i = 0$ and a 3x3 matrix for $i = \{1,2,3,4\}$.

The optimal number of lags (four) was chosen based on a likelihood ratio test. The orthogonalized impulse response functions are generated by specifying an appropriate ordering in the Cholesky decomposition. In practice, the y_t vector indicates the ordering in each of the above VAR analyses. For example, the identification assumption for the energy import VAR is as follows. First, energy prices influence all other three variables in the same period. Second, domestic energy production influences domestic energy consumption and energy imports in the same period but not energy prices. Third, domestic energy consumption influences energy imports in the current period but not the other two variables.

ENDNOTES

[1]See Brown for additional information on the history.

[2]The EIA annually projects energy production over the next 20 to 25 years.

[3]For detailed definitions of crude oil, natural gas plant liquids, dry natural gas, and other energy-related products, see EIA's website *http://www.eia.gov/tools/glossary/index.cfm?id=C.*

[4]Net import projections are calculated as consumption (petroleum and other liquids and natural gas) minus production (crude oil and lease condensate, natural gas plant liquids, and dry natural gas). Actual net imports are calculated as consumption (petroleum and natural gas) minus production (crude oil, natural gas plant liquids, and dry natural gas).

[5]Net imports were 10.5 quadrillion Btu in 1972, 31.1 quadrillion Btu in 2005, and 17.6 quadrillion Btu in 2013.

[6]For studies using a similar approach, see Ahearne, Fernald, Loungani, and Schindler; Aydın, Çıplak, and Yücel; and Nie and Taylor.

[7]Given the short data set, the VAR analysis on energy imports and exports does not include the real exchange rate (it does include the relative energy price). In addition, when including the real exchange rate, a Wald test shows it cannot reject all the coefficients, for the four lags of the real exchange rate are all zero, suggesting the dependence of energy imports and exports on the real exchange rate is not statistically significant.

[8]More precisely, this effect is not statistically significant at a 90 percent confidence level but becomes statistically significant at an 85 percent confidence level. The insignificance of the estimate is due, in part, to limited observations in the sample, as the estimation of the import dynamics only uses quarterly data since the first quarter of 2006.

[9]The EPCA limits only crude oil, not processed products. To export natural gas, companies must apply with the Department of Energy's Office of Fossil Energy (per the Natural Gas Act of 1938). Applications to export natural gas to any country with which the United States has an established free-trade agreement (FTA) are automatically approved (U.S. Code). Applications to export to non-FTA countries are approved as long as they are "consistent with the public interest," after a period of public comment.

[10]Even if the United States does lift the ban, these results could only give a partial answer to the question of how much energy exports would increase. Lifting the ban could be considered a significant structural change, in turn changing the model's estimated parameters.

[11]In the non-energy component forecasts, real foreign demand growth is assumed to be more correlated with total real export growth than real non-energy export growth. Thus, the forecasts of foreign demand growth are generated by

VARs using total real export growth. Similarly, the same assumption applies to the forecasts of domestic demand growth.

[12]The EIA forecasts domestic energy production and domestic and foreign energy consumption. Its forecasts are similar to the unconditional forecasts reported here. The EIA forecasts for domestic energy production and consumption are based on forecasts for U.S. domestic crude oil production and U.S. dry natural gas production, and U.S. petroleum consumption and U.S. natural gas consumption, respectively. These forecasts are released in the EIA's Short-Term Energy Outlook. EIA forecasts for world and U.S. petroleum demand were used to construct the forecast for foreign petroleum demand. All forecasts were collected from Haver Analytics.

[13]The relatively small effect of changes in energy export growth on total export growth is due to the currently small share of energy exports in total exports. However, given the persistent and strong growth in energy exports in recent years, the share of energy exports is expected to continue to increase.

[14]The procedure for generating conditional forecasts is similar to Del Negro and Schorfheide; Clark and McCracken; and Waggoner and Zha. The key assumption is that shocks to energy production, rather than to other variables, drive the increase in energy production. In practice, the simulation first finds a sequence of energy production shocks that lead energy production growth to increase 1 percentage point in each quarter of 2014 and 2015. Then, using these shocks and tracking interactions among current and past values of all variables, the simulation shows how energy import and export growth would have evolved over the forecast horizon. Finally, the differences between the conditional and unconditional forecasts capture the effects of the increase in energy production on forecasting variables.

[15]The slightly lower energy export growth in the 2015 conditional forecast is due partly to a larger drag of past energy export and production growth and partly to a smaller contribution from shocks to current energy production growth. The larger drag from past energy export and production growth is a result of the VAR estimation, which shows that current energy export growth negatively depends on past energy export and production growth. The smaller contribution from the shocks to current energy production is due to the smaller shocks required to increase energy production growth by 1 percentage point in 2015, taking as given the changes in other variables, which also influence energy production growth.

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