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The Potential Macroeconomic Impact of the Unconventional Oil and Gas Boom in the United States

by Benjamin Hunt, Dirk Muir, and Martin Sommer

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Abstract

This paper uses two of the IMF's structural macroeconomic models to estimate the potential global impact of the boom in unconventional oil and natural gas in the United States. The results suggest that the impact on the level of U.S. real GDP over roughly the next decade could be significant, but modest, ranging between 1 and 1½ percent. Further, while the impact on the U.S. energy trade balance will be large, most results suggest that its impact on the overall U.S. current account will be negligible. The impact outside of the United States will be modestly positive on average, but most countries dependent on energy exports will be affected adversely.

JEL Classification Numbers: D58, E27, E37, F41, F47, Q43

Keywords: business cycle, energy consumption, energy prices, general equilibrium models, macroeconomic interdependence, monetary policy, oil shocks, policy

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I. INTRODUCTION

The boom in unconventional energy, including shale gas and tight oil, has generated speculation that the United States could significantly reduce its dependence on foreign sources of energy and potentially even become energy self sufficient.[1] This paper uses two of the IMF's structural macroeconomic models, the Global Economy Model (GEM) and the Global Integrated Monetary and Fiscal Model (GIMF), to estimate the potential global impact of the increased production of oil and natural gas from unconventional sources in the United States. The analysis focuses on medium-term macroeconomic effects, and is not meant to explain short-run developments in the oil market.[2] Forecasting future unconventional energy production is fraught with many uncertainties and thus this paper simply assumes—motivated by upside scenarios of outside analysts—that the United States can move to energy self sufficiency over a twelve year period. This assumption may be optimistic, but it provides a useful benchmark to gauge the magnitude of possible macroeconomic effects. The framework developed in this paper provides the basis for examining several key factors that will determine the impact that such a development could have on global growth and imbalances.

Both GIMF and GEM are useful tools for estimating the potential impact of increased U.S. energy production. Both are fully structural models of the global economy in which energy plays a vital role as an input to the production of goods and services as well as a good that is also consumed directly by households. With household and firm behavior as well as global trade based on fully optimizing foundations, the estimates of the potential macroeconomic outcomes capture the general equilibrium implications nationally and globally not only for output but for global imbalances as well. In both models the price of energy is determined solely by current supply and demand conditions, abstracting from other important short-run factors such as expectations about future demand and supply developments or storage capacity. Consequently, the models are best suited for studying the medium-term implications of developments in energy supply and demand. Additionally the two models have some important differences that highlight some key factors that will influence the domestic and global impact of higher U.S. energy production.

The simulations results suggest that should U.S. unconventional energy production increase sufficiently to help achieve energy self sufficiency, sustainable output would rise by between roughly 1 and 1½ percent in the United States and just under ¼ percent in the rest of the world relative to a baseline in which this increase in U.S. production does not occur. The magnitudes of the real GDP effects will depend crucially on the impact that the increased U.S. production has on real energy prices, which partly reflects supply decisions by other

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[1] Shale is fine-grained sedimentary rock that can be rich in oil and natural gas, but because of its low permeability the contained oil and gas does not flow easily to wells without the use of advance drilling and extraction techniques.

[2] For example, this analysis cannot explain the sharp decline in oil prices that occurred in late 2014 which resulted from a range of demand and supply factors that are discussed in Blanchard and Arezki (2014).

global energy producers. In response to increased U.S. production, should other global suppliers reduce supply by more than assumed here, then the output benefits in United States and elsewhere would be smaller than these estimates suggest. On the other hand, should global suppliers respond by less, the impact would be larger. As for the natural gas market, the larger is the cost advantage enjoyed by the United States in natural gas prices owing to the export-cost wedge (liquefaction and transportation costs), the larger will be the share of the benefits that will be captured by the United States and the smaller will be the benefits in the rest of the world. In turn, energy exporters other than the United States would be affected less adversely.

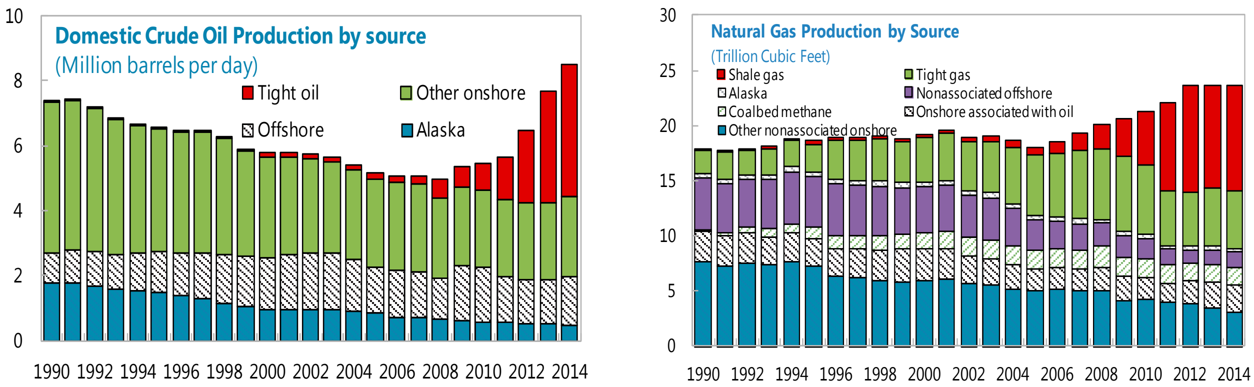
In terms of the impact on the U.S. external position, the results illustrate that although the U.S. energy trade balance will improve, the implications for the overall current account during the period of increased U.S. energy production will depend on how quickly households and firms come to understand the prospects for future U.S. energy production and the associated implications for energy prices and wealth. The estimates for the impact on the overall current account during the transition phase range from a very small improvement to a substantial deterioration. However, the most likely case is that firms' and households' understanding of the implications of the unconventional energy boom will unfold gradually and this will imply little impact on the overall current account balance despite notable improvement in the energy balance during the transition phase. In the long run, the estimates suggest that U.S. current account will deteriorate mildly as U.S. households choose not to finance the full increase in the U.S. capital stock that results from increased energy production.

The remainder of the paper is structured as follows. Section II contains a brief summary of the key developments in U.S. energy production that are motivating the analysis. Section III presents an overview of the two analytical models, highlighting the models' similarities as well as the key differences that have important implications for the analysis. Simulation experiments designed to estimate the potential impact of higher U.S. energy production on U.S. and global real GDP as well as global imbalances are presented in Section IV. Section V contains some brief conclusions.

II. U.S. PRODUCTION OF TIGHT OIL AND SHALE GAS[3]

The United States has experienced rapid growth in oil and gas production. Technological advances (especially horizontal fracturing and drilling) have helped to unlock unconventional oil and gas from shale formations (Box 1), reversing a long period of production declines. Total oil liquids production[4] has increased by roughly 50 percent over the past 5 years, helping to halve the U.S. imports of crude oil and related products. The natural gas sector has been booming as well, with output up by about one quarter.

Figure 1: Crude Oil and Natural Gas Production



Source: EIA

Source: EIA

Most forecasters expect substantial increases in the production of unconventional oil and gas, although projections differ substantially. In the EIA's central scenario developed before the recent oil price drop, U.S. domestic production of energy from both conventional and unconventional sources was projected to increase by about 15 percent over the next decade, but in a high production scenario, the increase could be roughly 25 percent (Figure 2). The differences reflect a variety of uncertainties related to both technology and policy:

- *Scalability*. The shale fields typically have very high depreciation rates (production can drop 60-80 percent after the first year) and production will eventually need to move from sweet spots to less-productive areas.

- *Environmental concerns*. Hydraulic fracturing is a process involving injections of large quantities of water, sand, and chemicals into wells. Opponents of "fracking" point to limited water resources, the environmental risks from toxic chemicals and more frequent earthquakes.

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[3] This section draws on Hunt and others (2013).

[4] Total liquids include crude oil, natural gas liquids, nontraditional oil such as extra heavy oil, gas-to-liquids and coal-to-liquids, and biofuels such as ethanol.

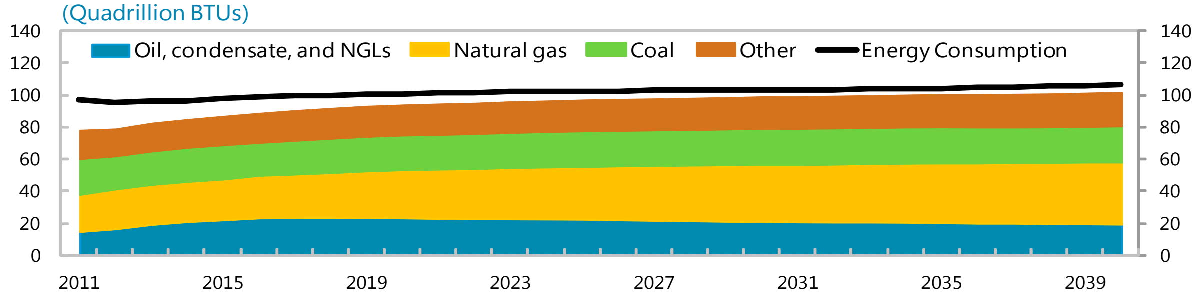
- *Infrastructural bottlenecks*. The U.S. pipelines were designed to carry oil and refined gasoline from coasts to the interior. These pipelines were not well-equipped to handle the increased amount of crude from shale reserves located outside of the traditional production areas, although some of these infrastructural bottlenecks have eased.

Figure 2 illustrates the forecasted increases in U.S. oil and natural gas production until 2040. Given the uncertainty regarding the precise magnitude of the future growth in U.S. unconventional energy production, the simulation analysis that follows will estimate the potential impact of the United States moving to energy self sufficiency. While it is unclear if energy self sufficiency will in fact materialize, and if it does, at what speed, this assumption provides a useful benchmark for gauging the potential macroeconomic impact. Under the EIA reference scenario, the United States remains a net importer of energy over the projection period until 2040. The United States would become a net energy exporter in the EIA's high oil and gas resource scenario by the mid-2020s.

Figure 2: U.S. Energy Production Forecasts by the EIA

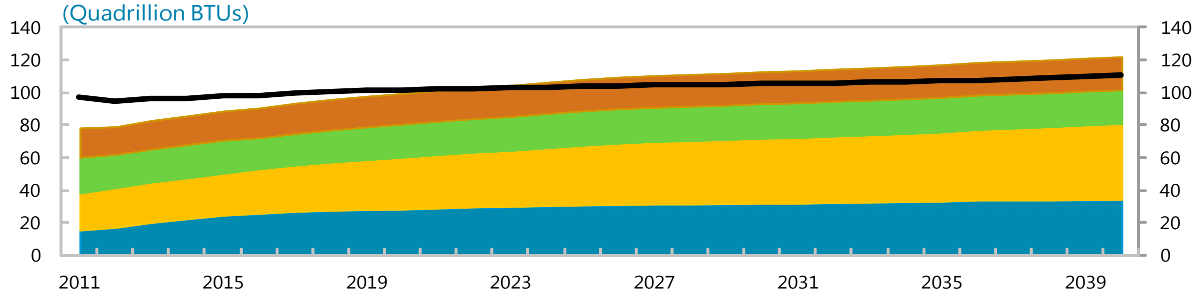
EIA Reference Case

(Quadrillion BTUs)



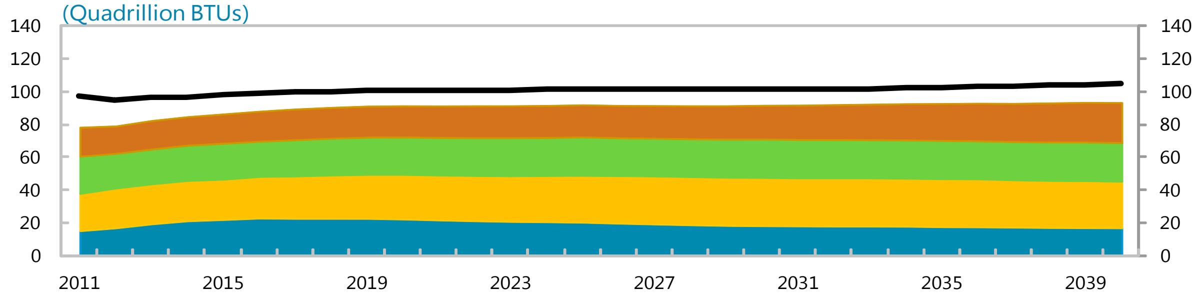
EIA High Production Case

(Quadrillion BTUs)



EIA Low Production Case

(Quadrillion BTUs)



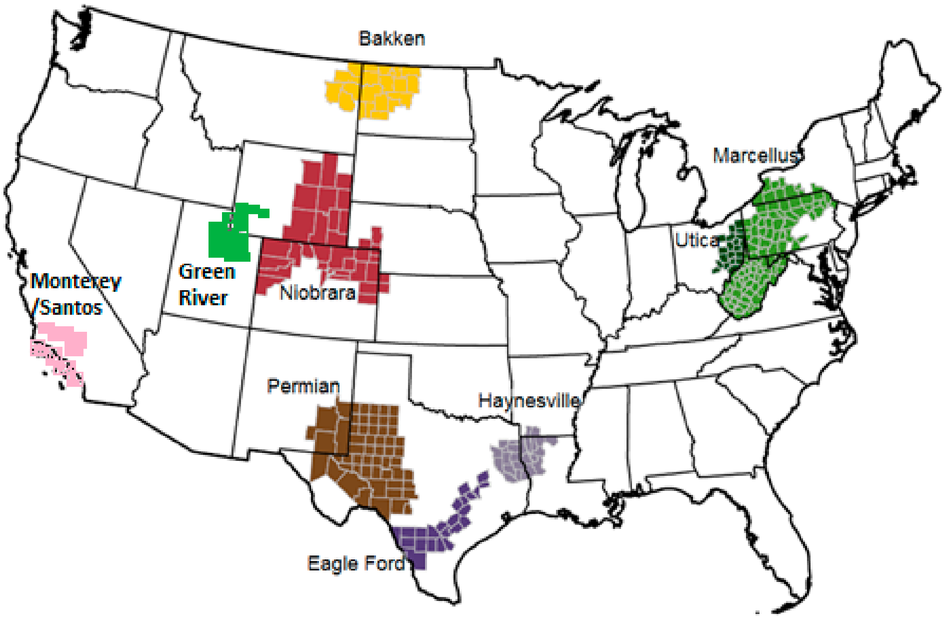
Source: Energy Information Agency

Box 1. What are shale gas and tight oil?

Shale formations are sedimentary rocks which can be rich in oil and natural gas. However, due to their low permeability, the oil and natural gas contained in these rocks will not easily flow to wells without assistance from advanced drilling techniques such as hydraulic fracturing and horizontal drilling. Hydraulic fracturing involves pressurized injection fluids commonly made up of water, sand and chemical fluids. This mix is injected under high pressure, down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer to crack. The fissures are held open by the sand particles so that “tight oil” or “shale gas” flows back to the well.

- The largest U.S. technically recoverable ***tight oil formation*** is Monterey/Santos in Southern California, which is estimated to hold approximately 64 percent of U.S. tight oil reserves. The next largest tight oil formations are Bakken in western North Dakota and eastern Montana, and Eagle Ford in southern Texas.

- Most ***shale gas*** resources are located in the North East, Gulf Coast and Midwest regions. These regions accounted for 95% of domestic oil and gas production growth between 2011 and 2013. The Marcellus field in the North East is the largest natural gas source in the United States.



Source: Energy Information Agency, American Petroleum Institute, and Bureau of Land Management.

III. SUMMARY OF THE MACROECONOMIC MODELS

Given the forecasts for increases in oil and natural gas production for the United States, both the Global Economy Model (GEM) and the Global Integrated Monetary and Fiscal Model (GIMF) are used to analyze the potential impact of the shale boom on the U.S. and global economies. Brief overviews of the two models are presented in this section. Although the models share many similar features, there are important differences. To ease the exposition, the models' shared features are described first, followed by their key differences.[5]

A. The Common Features of GEM and GIMF

Both models are multiple good, dynamic stochastic general equilibrium (DSGE) models with optimizing behavior by households and firms, and full intertemporal stock-flow accounting. Frictions in the form of sticky prices and wages, real adjustment costs, and liquidity-constrained households imply an important role for monetary and fiscal policy in economic stabilization.

The models encompass the entire world economy, explicitly modeling all the bilateral trade flows and their relative prices for each region, including exchange rates. The models comprise 6 regions - the United States, the euro area, Japan, emerging Asia, Latin America, and a block of the remaining countries, which also includes many oil exporters.[6] The international linkages in the models allow the analysis of spillovers at the regional and global level.

Firms

Firms employ capital, labor and commodity inputs to produce tradable non-commodity goods and nontradable goods. Production technology is described by a constant elasticity of substitution production function where commodity inputs enter in an additively separable fashion. The elasticity of substitution between capital and labor is close to one, but the elasticity of substitution between the capital-labor bundle and the commodity input can be different, generally much lower. Firms face costly adjustment on labor and commodity inputs and investment as well as on nominal output prices and wages. Firms operate in monopolistically competitive markets and thus prices contain a markup over marginal costs. In additional, firms hire in labor markets that are also monopolistically competitive and therefore wages contain a markup over the marginal rate of substitution between consumption and leisure.

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[5] The interested reader can find a detailed exposition of the theoretical structure of GEM as well as several practical applications in IMF (2008). For detailed documentation on the structure of the model see Kumhof and others (2010). For details on the model's properties see Anderson and others (2013).

[6] In the models, the euro area consists of Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Italy, Ireland, Luxemburg, Netherlands, Portugal, Slovenia, Slovakia, and Spain. Emerging Asia consists of China, Hong Kong Special Administrative Region of China, Indonesia, India, the Republic of Korea, Malaysia, Singapore, the Philippines, Thailand, and Taiwan Province of China. Latin America includes Brazil, Chile, Colombia, Mexico, and Peru. The remaining countries block includes other countries not elsewhere included.

Financial Structure

Asset markets are incomplete in the models. Government debt is only held domestically, as nominal, non-contingent, one-period bonds denominated in domestic currency. The only assets traded internationally are nominal, non-contingent, one-period bonds denominated in U.S. dollars that can be issued by the U.S. government and by private agents in any region. Firms are owned domestically. Equity is not traded in domestic financial markets; instead, households receive lump-sum dividend payments. There is a financial sector similar to Bernanke, Gertler and Gilchrist (1999), that incorporates a procyclical financial accelerator, with the cost of external financing facing firms rising with their indebtedness.

In the short run, the nominal exchange rate is driven by uncovered interest parity in both models. However, uncovered interest parity does not always hold, due to the presence of country risk premiums. The premiums can create deviations, both in the short run and the long run, between interest rates in different regions, even after adjustment for expected changes in nominal exchange rates. In the long run, the real exchange rate is the key relative price that adjusts to ensure external stability.[7]

Policy

Fiscal policy in the models is conducted using a variety of expenditure and tax instruments. Government spending may take the form of either consumption or investment expenditure, or lumpsum transfers to households. Revenue accrues from the taxes on labor and corporate income, consumption taxes, and lumpsum taxes. Government investment spending augments public infrastructure, which depreciates at a constant rate over time. Fiscal policy rules ensure long-run sustainability, while allowing for short-run counter-cyclical policies. The rules can be implemented with any or several of the fiscal tax and expenditure measures used as the instrument. The default version of the policy rule in both models uses transfers as the instrument. The fiscal rules ensure that in the long run, the government debt-to-GDP ratio—and hence the deficit-to-GDP ratio—eventually converges to its target level. The rules also allow for countercyclical fiscal policy as they embody automatic stabilizers.

The base-case versions of the models are set up such that central banks use an inflation-forecast-based interest rate rule. Central banks vary the gap between the actual policy rate and the long-run equilibrium rate to achieve a stable target rate of inflation over time. However, the models can also be set up such that central banks (outside the United States) stabilize the nominal U.S. dollar exchange rate.

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[7] Some major oil and gas exporting countries, for example those in the Middle East and North Africa region, have fixed exchange rate regimes. This aspect is not modeled here.

Energy Sector

In both models, the price of energy clears the market on the basis of contemporaneous supply and demand. There is no inventory accumulation or storage for energy. This assumption eliminates the role of expectations in driving energy prices, making the models more useful in analyzing medium-term equilibrium, rather than short-term price movements.

Parameter Values

Parameter values for both models are derived through calibration. Specific parameter values are determined by balancing several factors: empirical estimates available in the literature, the desired steady-state characterization of the economies, and the models' dynamic adjustment properties. The calibration of key steady-state ratios such as expenditure and production shares of GDP and trade relationships amongst the six regions are based on data as of end-2011. Empirical evidence on markups has also been incorporated into the calibration. Many behavioral parameters that do not affect expenditure shares or trading relationships have been set identically in all regions. However, region-specific nominal and real adjustment cost parameters along with different proportions of liquidity-constrained households and different markups in goods and labor markets contribute to nominal and real dynamics that differ across regions.

B. The Key Differences between GEM and GIMF

The main behavioral differences between GIMF and GEM lie in the characterization of households and the structure of production in the energy sector. In addition, GEM is a quarterly model whereas GIMF is annual.

Households

In both GIMF and GEM there are two types of households, those that have access to capital markets and those that do not, referred to as liquidity-constrained (LIQ) households. The LIQ households do not save and have no access to credit. The consumption of LIQ households is equal to their current net income, so their marginal propensity to consume out of current income is unity by construction. The households in both models that have access to capital markets save by acquiring domestic government bonds, international U.S. dollar bonds, and through fixed-term deposits. They maximize their utility subject to their budget constraint. Aggregate consumption for these households is a function of financial wealth (government bonds, the capital stock, and net foreign assets) and the present discounted value of after-tax wage and investment income.

The key difference in households between the two models is that in GEM all households are infinitely lived, whereas in GIMF household have finite planning horizons. Therefore, they over-discount the future. This has important implications for the valuation of government debt and thus the macroeconomic consequences of some fiscal policy actions as well as for the determination of global real interest rates and equilibrium net foreign asset positions.

Implications for fiscal policy

In GIMF, because households have a finite planning horizon, those that have access to capital markets respond differently to some fiscal policy measures that have implications for future taxes. For example, for households with finite-planning horizons, a tax cut has a short-run positive effect on consumption when the cuts are matched with a tax increase in the future that leaves government debt unchanged in the long run. In effect, households discount future tax liabilities at a higher rate than the market rate of interest. Thus, an increase in government debt today represents an increase in their wealth, because a share of the resulting higher taxes in the future is payable beyond their planning horizon. In GEM, however, a temporary tax cut today that is offset with an increase in taxes in the future that leaves government debt unchanged, will have no impact on the consumption of households that have access to capital markets. Those households simply save the tax cut today to cover the higher tax payments they know will fall on them in the future.

In both models, a tax cut today exactly financed with a tax increase in the future will result in the consumption of LIQ households increasing by exactly the amount of the tax cut today and falling by exactly the amount of the tax increase in the future. By assumption, these households simply consume their after-tax disposable income each period.

Implications for global real interest rates

In GEM, the infinitely-lived structure of households means that the global real interest rate is determined by the relative impatience of households and the equilibrium growth rate of the world economy. The more impatient households are for a given world equilibrium growth rate, the higher will be the global equilibrium real interest rate. So unless there is a permanent change in the degree of impatience of households, there is no movement of the real global interest rates in the long run.

In GIMF, the global real interest rate is pinned down by the interaction of the supply and demand for savings which arises because government bonds are perceived to be net wealth. If demand for savings grows because of increases in public debt or a higher desired level for the private capital stock, the global real interest rate needs to rise to induce households to increase savings.

Implications for net foreign assets

GEM’s basic open-economy structure with infinitely-lived representative households leads to long-run net foreign asset positions that are path dependent and thus a function of all the shocks that hit all the regions in the model. Consequently, these types of models have employed a number of solutions to ensure a stable steady state for net foreign assets (see Schmitt-Grohé and Uribe, 2003). In GEM, a financial friction along with an exogenously specified desired net foreign asset-to-GDP ratio is used to ensure the convergence to a stable steady state for the economy’s net external position. Essentially, it is assumed that households that take a position in the international bond market must pay an intermediation fee, the financial friction. The imposition of this fee, which increases as the economy deviates from its desired net foreign asset position, ensures that each region's net foreign asset position will converge back to its exogenously determined desired level.

With GIMF's finite-planning-horizon households, there is always a stable steady state for the economy's net foreign asset position that falls out of the optimization problem of those households that have access to financial markets. Consequently, regions in GIMF can be either net creditors or net debtors to the rest of the world in steady state. After temporary shocks, the dynamic adjustment path for the exchange rate will ensure that the region's net foreign asset position returns to its equilibrium. Under permanent shocks that change a region's equilibrium net foreign asset position, the dynamic path for the exchange rate will adjust to ensure that that the new equilibrium is achieved and, subsequently, the equilibrium exchange rate will adjust to ensure that the new equilibrium, once achieved, is stable.

Production of Energy

In GIMF, energy production is simply an endowment framework. Each region has a baseline endowment that can be used for the domestic production of non-energy goods, consumed directly, or exported. Although energy is an endowment, it is assumed that there are associated intermediate inputs that are consumed converting the endowment into a final usable product equal to 40 percent of the value. Consequently, in value added terms and assuming no change in relative prices, 60 percent of the increase in the energy endowment flows through to GDP.

In GEM, energy is produced with three factors – labor, capital, and a fixed factor often referred to as "land." Land simply represents a reserve of the resource that can be transformed into a tradable energy good using capital and labor.

Strictly speaking, the endowment model in GIMF implies a vertical (inelastic) energy supply function whereas the production model used for GEM implies a mildly upward sloping supply function. As the real price of energy falls in GEM, less will be produced.

C. Implications of the Models' Differences for Analysis of U.S. Unconventional Energy

The key differences in GIMF and GEM imply that they each can bring different insights into estimating the potential impact of growing unconventional energy supply in the United States. In GIMF, the endogenous net foreign asset position is useful for estimating the potential impact on the United State's net external asset position and current account balance. GEM on the other hand, because of its more elastic global energy supply curve, is more useful for estimating the potential impact on medium-term global energy prices. Both the impact on global energy prices and the impact on the U.S. external position are necessary to fully explore the potential consequences of U.S. unconventional energy for global growth and imbalances.

IV. SIMULATION ANALYSIS

In this section, simulations examine the potential macroeconomic impact of the United States moving to energy self sufficiency via higher production of unconventional energy. The scenarios all assume that the United States becomes energy self sufficient over the next twelve years. A number of scenarios are simulated to examine the various factors that could influence the magnitudes of the long-run impacts as well as the dynamic adjustment paths.

To make the GEM and GIMF simulations comparable, a number of preliminary simulations were run and are detailed in the Annex. Given the different energy production sectors in the two models, the simulation was first run on GEM to estimate the impact on the global energy price after allowing other global suppliers to respond to higher U.S. production. This response can represent the usual price elasticity of supply (some production is uneconomical at lower prices) or strategic behavior by large producers. The simulation was then run in GIMF, increasing the U.S. energy endowment while at the same time reducing the endowment in other energy producers so that the resulting impact on the global price of energy was similar to the result obtained from GEM. The long-run impact on the U.S. net foreign assets position from GIMF is then used to impose the change on the net foreign asset position in GEM. Output and current account effects are thus comparable across the two models in all the simulations presented below.

The simulations assume that the move to energy self sufficiency occurs over roughly 12 years and that tight oil and shale gas are perfect substitutes for imported energy. Given energy consumption and production in 2013**,** this implies an increase in U.S. domestic production of roughly 1.8 percent of GDP, or 0.4 percent of global GDP. In GIMF this is implemented by raising the endowment of energy by 0.15 percent of GDP each year for twelve years. In GEM, the fixed factor in energy production, usefully thought of as reserves, is gradually increased over a twelve-year period by enough so that once capital and labor have responded endogenously, U.S. energy production has increased by 1.8 percent of GDP.

A. Fully Anticipated Move to Self Sufficiency

This sub-section assumes that the increase in energy supply is fully anticipated, so that households and firms immediately understand that over the next 12 years the U.S. economy will become energy self sufficient. The results for several key macro variables from both models are presented in Figure 3 (blue line GEM results, red line GIMF results).

The first point to note is that the increase in U.S. energy supply leads to a declining global real price of energy. In addition to the direct impact on U.S. activity from increased energy production, the decline in the price of energy generates some indirect effects owing to the response of firms in the non-energy sector and households, as detailed below. In GEM, the direct and indirect impacts result in an immediate increase in real GDP despite the slight deterioration in the trade balance which reflects higher domestic consumption and investment. In GIMF however, the increase in non-energy imports offsets the impact of higher investment and consumption and lower imports of energy, leaving real GDP roughly unchanged initially. The fact that the non-energy net trade balance deteriorates more in GIMF reflects the fact that the real exchange rate appreciates more sharply in GIMF.

However, after several years, real GDP rises above baseline in GIMF. In the long run, the impact on U.S. real GDP is roughly equivalent in the two models, roughly 1.2 percent above the initial baseline.[8]

More specifically, when the increase in energy production is fully anticipated, firms understand that the cost of energy will be declining for an extended period of time and will be permanently lower in the long run. Consequently, with the decline in the cost of a key factor of production, firms will move along their supply curve, employing more capital and increasing the demand for labor. Real adjustment costs in investment encourage firms to start putting capital in place before all the declines in energy prices materialize. In addition to the resulting increased demand for investment goods, private consumption demand also rises because of rising household real incomes and wealth. Household real incomes and wealth rise because of the fall in energy prices, the increase in real wages owing to the increased labor demand, the appreciation of the currency which reduces import prices, and the increase in energy resources which are owned by the households.

The two models have markedly different responses of labor supply. In GEM, the substitution effect dominates and higher real wages induce households to supply more labor. In GIMF however, the income effect from the increased endowment of energy and higher real wages dominates, and labor supply falls. This reflects the fact that the specification of household utility in GEM is based on Greenwood, Hercowitz, and Huffman (1988) which limits the income effect of increases in real wages. Essentially the marginal utility of consumption depends solely on consumption and thus labor supply is only a function of the real wage. In GIMF, where the utility function is based on King, Plosser and Rebelo (1988) preferences, consumption and leisure are both normal goods with unit elasticity of substitution and, consequently, increases in wealth/income that raise consumption dominate the substitution effect of the higher real wage and labor supply declines. Given the decline in labor supply in GIMF, the real wage rises by more than in GEM as firms try to induce households to supply more labor.

In both GIMF and GEM the trade balance and current account deteriorate when the move to energy self-sufficiency is fully anticipated. The improvement in the energy balance is more than offset by the decline in the non-energy balance. While this result may appear surprising at first, Arezki, Ramey, and Sheng (2015) find that the current account balance indeed tends to deteriorate after major oil discoveries, using global data over 1970-2012. The declines in the trade balance and current account are larger in GIMF than in GEM. Although the long-run change in the U.S. net foreign asset position that occurs in GIMF is imposed on GEM, the dynamic adjustment path is quite different, the bigger consumption boom and the greater currency appreciation in GIMF lead to temporarily larger deteriorations in the trade and current account balances.

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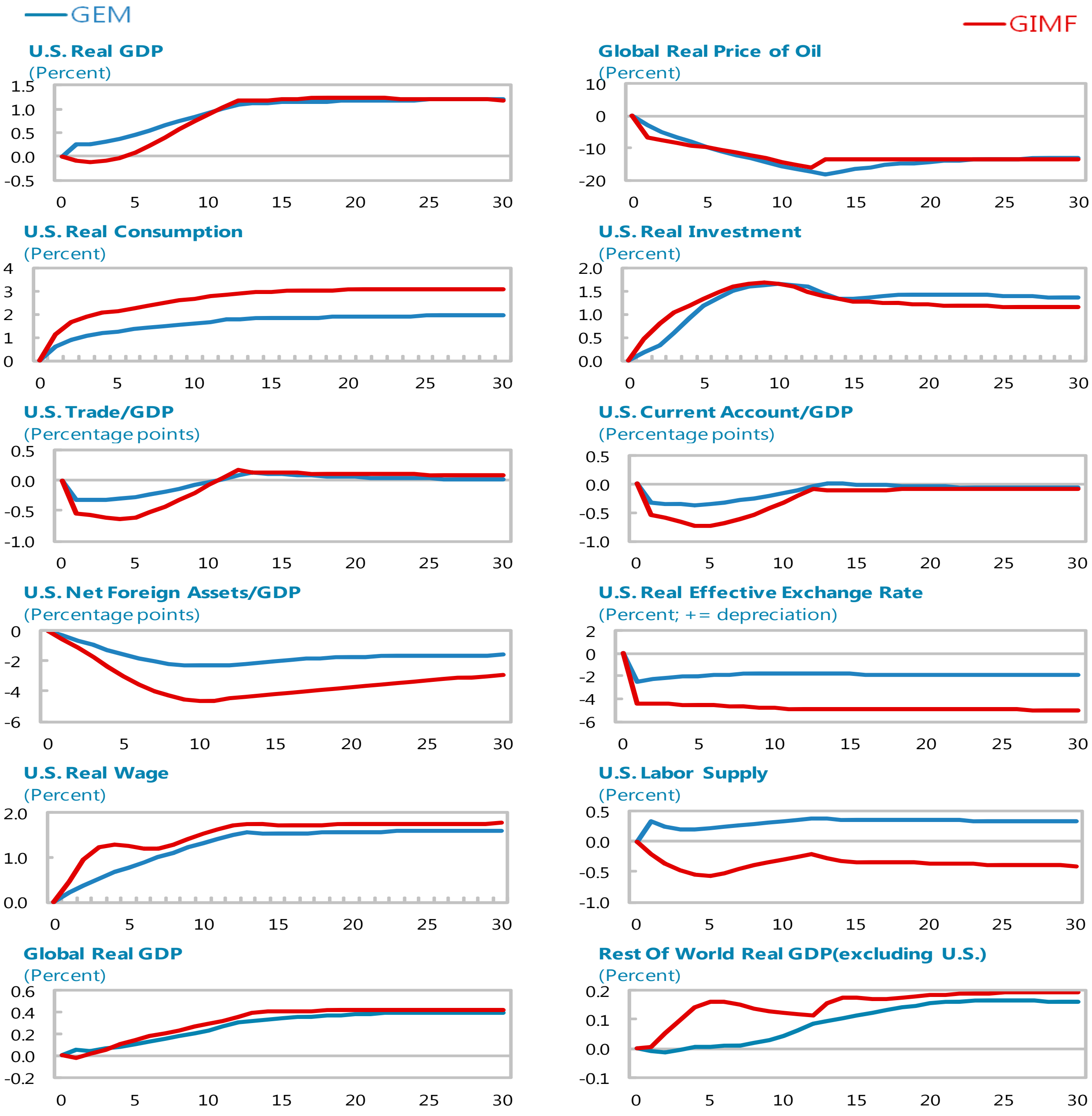
[8] In GEM the case where the increase in U.S. unconventional energy is driven by higher productivity rather than more reserves was also considered. However, the real GDP impact was virtually identical to the reserves case.

The lower global price of energy also has benefits outside the United States. Figure 3 contains the impact on global real GDP and global real GDP excluding the United States. Although global real GDP rises by 0.4 percent, a large portion of that accrues to the United States, with real GDP outside the United States rising by roughly 0.2 percent. The distribution of benefits across regions outside the United States depends on their net trade position in energy, with net energy importers benefiting, and net energy exporters either benefiting or losing depending on their trade structure. Countries highly dependent on energy exports and limited fiscal and external buffers would be affected adversely (see, for example, IMF, 2015).

Figure 3: United States Fully Anticipated Move to Energy Self Sufficiency



Source: Authors' calculations

B. Unanticipated Move to Self Sufficiency

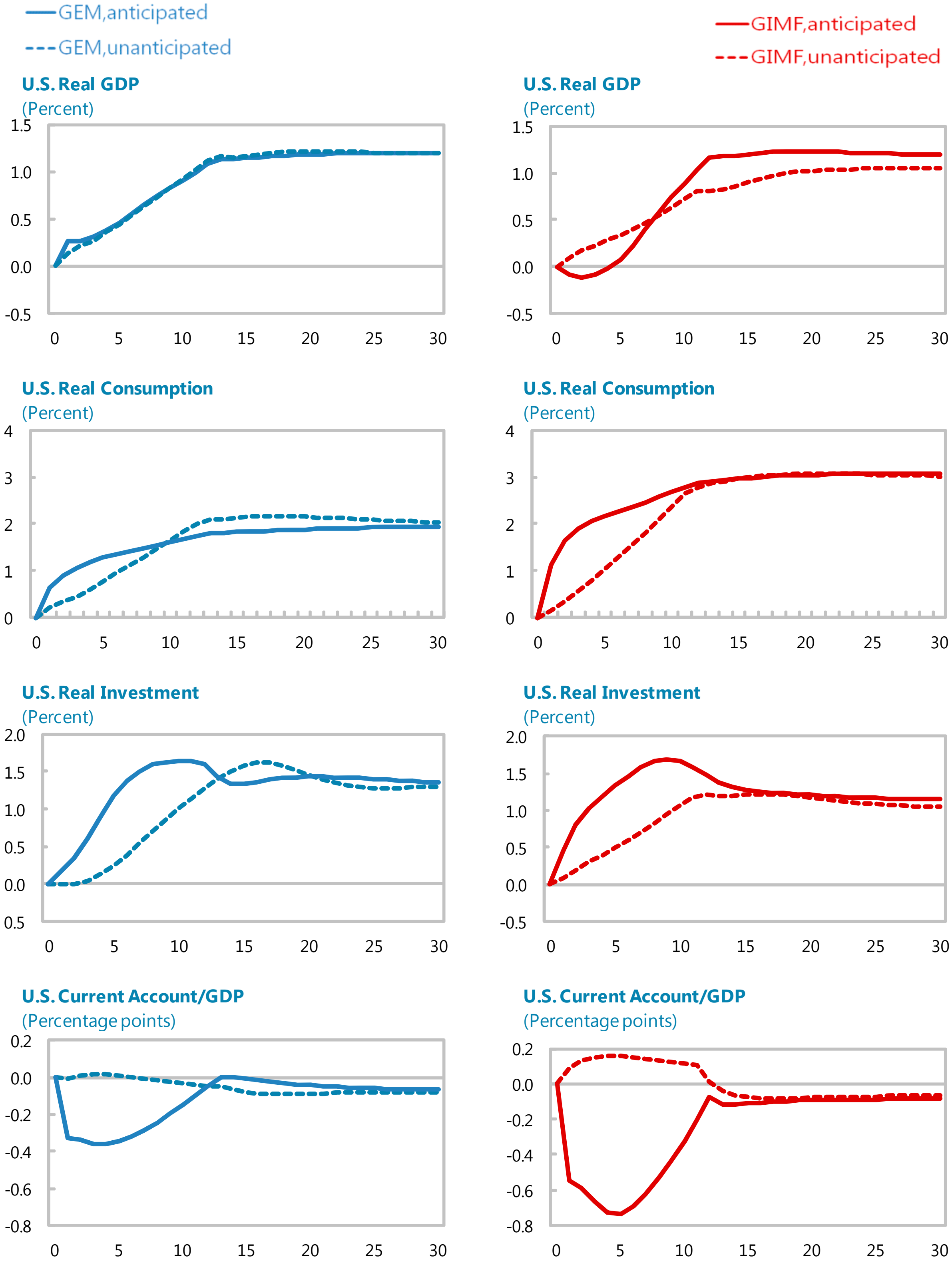
This sub-section assumes that the increase in energy supply is not anticipated, so that households and firms are surprised each period when U.S. energy production turns out to be higher than in the previous period. During the initial stages of the boom in unconventional energy, this is likely the more realistic assumption and in fact the learning process could be quite gradual over the entire transition phase. The results for several key macro variables from both models are presented in Figure 4.

As occurred under the anticipated case, the real global price of energy declines on impact and continues to decline over the whole period during which U.S. energy production is increasing. However, it is important to note that in each period, the decline in the price of energy comes as a surprise and, consequently, the responses of households and firms are quite different relative to the fully anticipated case. In both models when the increase is unanticipated, consumption and investment rise more gradually and the currency appreciates to the new long-run level slowly. As a result, both the trade balance and the current account improve rather than deteriorate in the short to medium term. This difference is more pronounced in GIMF relative to GEM. As a result, output rises immediately on impact in GIMF as the trade balance adds to real GDP rather than fully offset the increase in domestic demand as it does under the anticipated case. In GEM, the improvement in the trade balance is not large enough to compensate for the weaker response of domestic demand and the initial increase in output is smaller relative to the fully anticipated case.

Under the unexpected increase in unconventional energy production, households' labor supply response is much more gradual. In GEM, firms do not foresee the future decline in energy prices and so their desired capital stock does not increase as rapidly and as a result nor does their labor demand. This results in a slower increase in real wages and thus the rise in labor supply occurs more gradually. In GIMF, households only learn about the increase in their wealth over time and as a result do not quickly raise consumption and reduce labor supply (increase leisure).

The more modest initial responses of both investment and consumption in both models lead to an improvement in the current account and net foreign assets. The improvement in the current account is much larger in GIMF, and relative to the anticipated case, the swing in the current account is roughly 1 percent of GDP over the period where energy production is increasing. However, the improvement in the current account is temporary and once there are no more surprise increases in energy production, the current account moves into deficit because U.S. households prefer not to fully financing the increase in the capital stock that would result from the move to energy self-sufficiency. In the long run, the current account and net foreign asset positions converge to the same values as under the fully anticipated case since households' long-run desired asset positions are identical. In GEM, the current account also eventually shifts to deficit and the net foreign asset position converges to its imposed long-run value.

Figure 4: United Sates Anticipated versus Unanticipated Move to Energy Self-Sufficiency

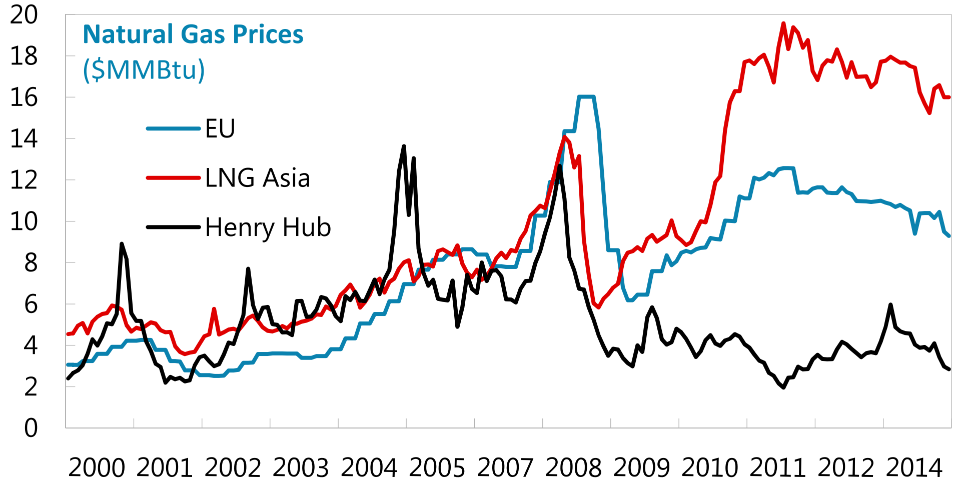


Source: Authors' calculations

C. Partially Segmented Markets

The benefits from higher U.S. unconventional energy production could accrue more to the United States than estimated in the previous simulation analysis. Those simulations assume a single global market for oil and natural gas. However, real factors exist that have led to a decoupling of U.S. natural gas prices from those in other regions of the world (see Figure 5). Limited infrastructure for the liquefaction and export of natural gas as well as the additional costs of doing so, help explain a portion of the price differential. To the extent this price differential persists in the future, the United States will gain more benefits from the exploitation of unconventional energy than estimated under the assumption of a single global market. To estimate how much larger those benefit might be, additional simulations are considered that allow for a wedge between the U.S. price of energy and the global price that reflects the cost of liquefaction and transportation of U.S. natural gas. The simulation results for several key macro variables are presented in Figure 6.

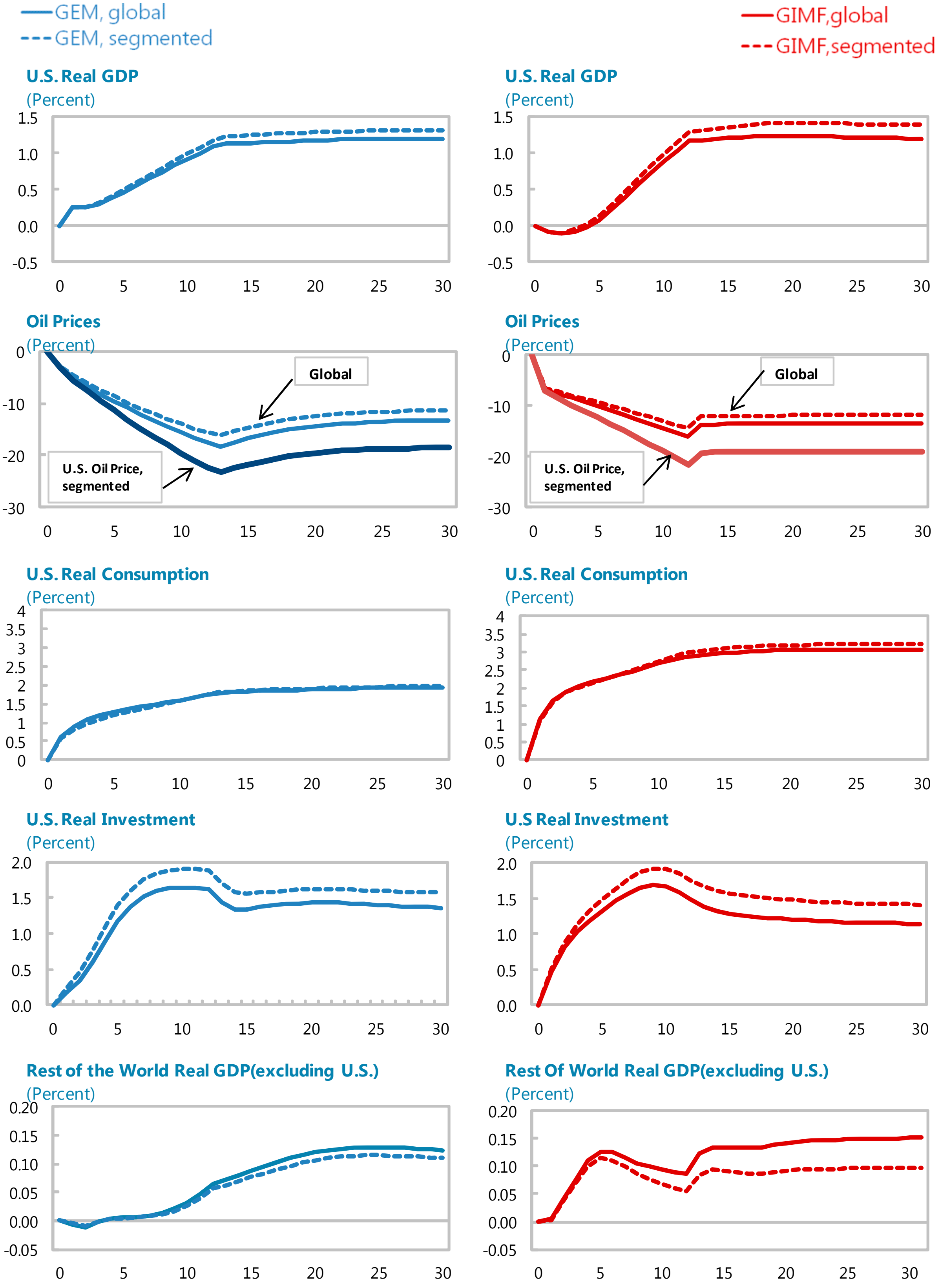
Figure 5: Natural Gas Prices in Key Global Regions



Source: IMF, World Economic Outlook

In the simulation it is assumed that the cost wedge leads to U.S. energy prices falling by roughly twice as much as the global price. The additional decline in U.S. energy prices induces even more non-energy investment and production in the United States. Higher real wages also support more private consumption. Real GDP rises by roughly an additional 0.2 percent relative to the case of a global market and common global price. The flip side of this is that real GDP does not rise by as much in the rest of the world since the decline in the global price of energy is smaller. However, the difference is quite small on average. Generally, net energy importers benefit less and energy exporters are better off relative to the case of the single global market. Within this broad assessment, experiences of individual countries would differ substantially depending on their reliance on energy exports/imports.

Figure 6: Partially Segmented Energy Markets



Source: Authors' calculations

V. CONCLUSIONS

The increased extraction of tight oil and shale gas in the United States has had important implications for the U.S. and global economies. While it is not possible to precisely forecast how much of the United States' energy needs will be satisfied from unconventional domestic sources, it is useful to attempt to quantify possible macroeconomic effects over the medium term. To do so, two of the IMF's fully structural models, GIMF and GEM, have been used to estimate what the impact might be if the United States achieved energy self sufficiency through higher production of unconventional oil and gas.

The model-based estimates suggest that although the impact on U.S. and global real GDP is nontrivial, it is likely to be modest. Real GDP in the United States is estimated to increase by between 1 and 1½ percent over the longer term, with the impact on real GDP outside the United States to be less than ¼ percent. This is consistent with the modest long-term macroeconomic effects in the United States estimated by a recent study by the Congressional Budget Office (CBO, 2014). That said, the adverse impact on countries highly depend on oil exports could be very large (IMF, 2015). The estimates are subject to uncertainty due to several factors such as the response of other global energy suppliers to the increase in U.S. production, the degree of price advantage enjoyed by the United States owing to the cost of liquefaction and transportation of natural gas, and the possibility of difficult-to-model structural changes such as reallocation of petrochemical industries to the United States.

The impact on global imbalances is estimated to be small. Although the U.S. energy balance will improve modestly, the impact on the overall U.S. current account is ambiguous in the short run and will depend critically on people's expectations of future U.S. energy production prospects. Should households and firm fully anticipate the increased U.S. energy production, the current account could deteriorate during the transition phase by up to 1 percent of GDP. However, it is more likely that understanding of the full implications of the unconventional energy boom will evolve gradually over time and the estimates suggest that this gradual learning would lead to a mild improvement in the current account during the transition phase. In the long run, the estimates suggest a mild deterioration in the overall U.S. current account as U.S. households would not want to finance the full increase in the capital stock that would result from the move to energy self sufficiency.

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ANNEX: PRELIMINARY SIMULATIONS

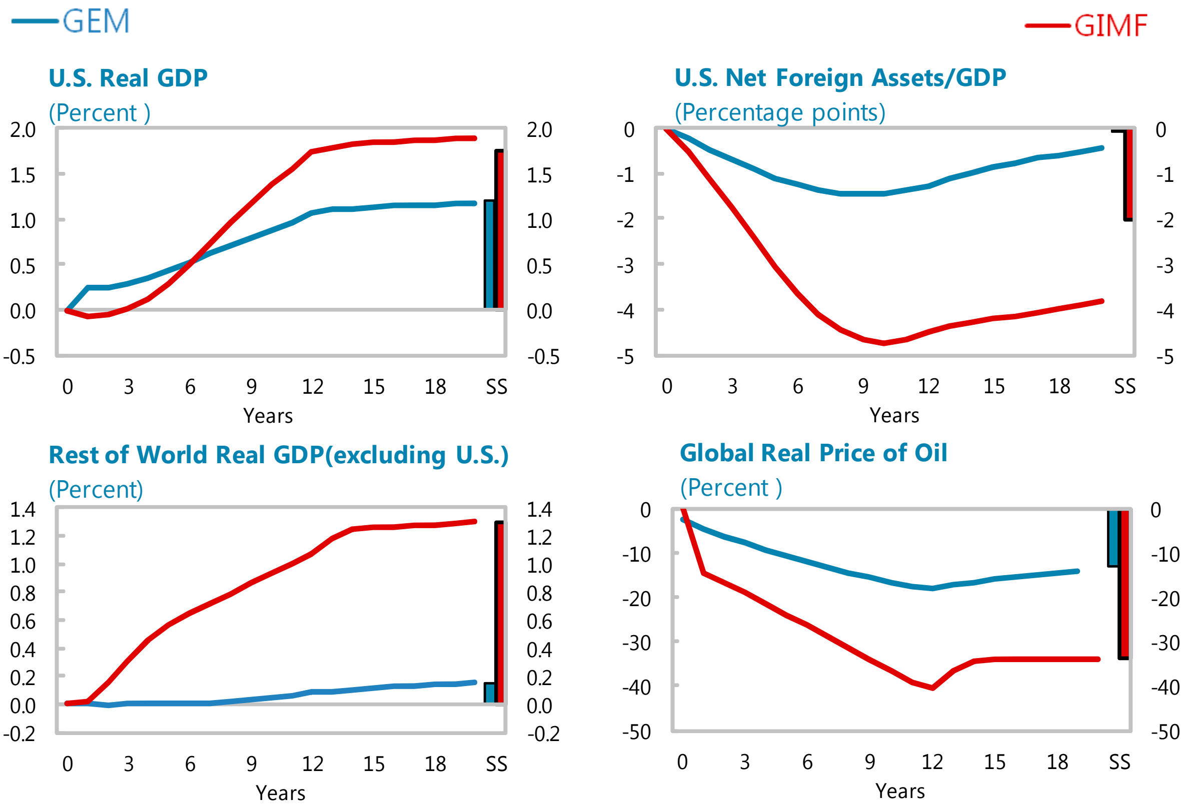
This annex details the preliminary simulations prepared to establish consistency between GEM and GIMF simulations.

A. Initial Energy Self Sufficiency Simulations

The simulation assumes that the move to energy self sufficiency occurs over roughly 12 years and that tight oil and shale gas are perfect substitutes for imported energy. Given energy consumption and production in 2013, this implies an increase in U.S. domestic production of roughly 1.8 percent of GDP. In GIMF this is implemented by raising the endowment of energy by 0.15 percent of GDP each year for twelve years. In GEM, the fixed factor in energy production is gradually increased over a twelve-year period by enough so that once capital and labor have adjusted, U.S. energy production has increased by 1.8 percent of GDP.

The results for several key macro variables from both models are presented in Figure 7 (blue line GEM results, red line GIMF results).

Figure 7: Initial GIMF and GEM Simulations of Move to U.S. Energy Self Sufficiency



U.S. Real GDP
(Percent)

U.S. Net Foreign Assets/GDP
(Percentage points)

Rest of World Real GDP(excluding U.S.)
(Percent)

Global Real Price of Oil
(Percent)

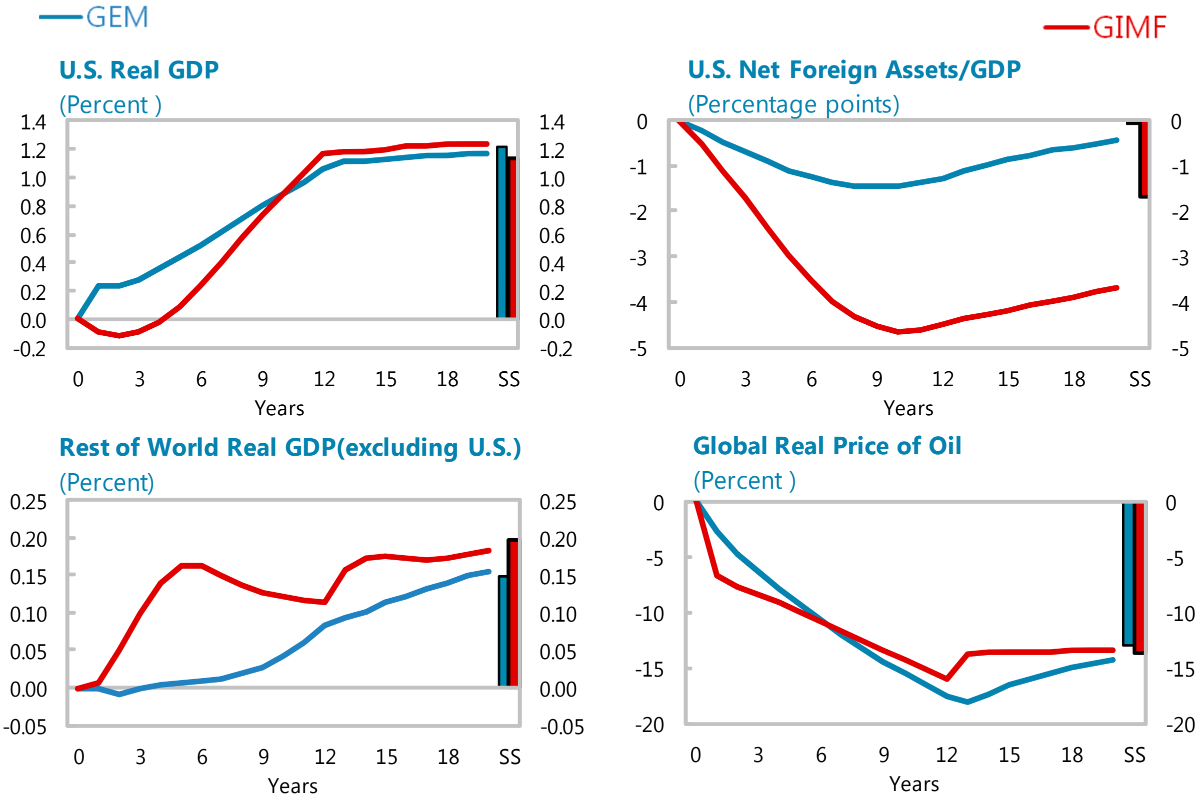
Source: Authors' calculations

The first point to note is that the increase in U.S. energy supply leads to a quickly declining global real price of energy. In GIMF, the inelastic international energy supply function means that the decline in the price of energy is more than double the decline under GEM's more elastic characterization of energy supply. With the much larger decline in energy prices arising from the increase in U.S. production in GIMF, the impact on real GDP is much larger in both the United States and the rest of the world. However, the responses of other energy producers and thus the energy price and real GDP effects are more plausible in the GEM results.

B. More Realistic Response of Rest-of-World Energy Suppliers in GIMF

To bring the two models results closer together, the GIMF simulation is repeated reducing the energy endowments in regions outside the United States such that the GIMF outcome for the global price of energy closely approximates that of GEM. These results are presented in Figure 8.

Figure 8: GIMF's Rest-of-World Energy Suppliers' Response Matching GEM



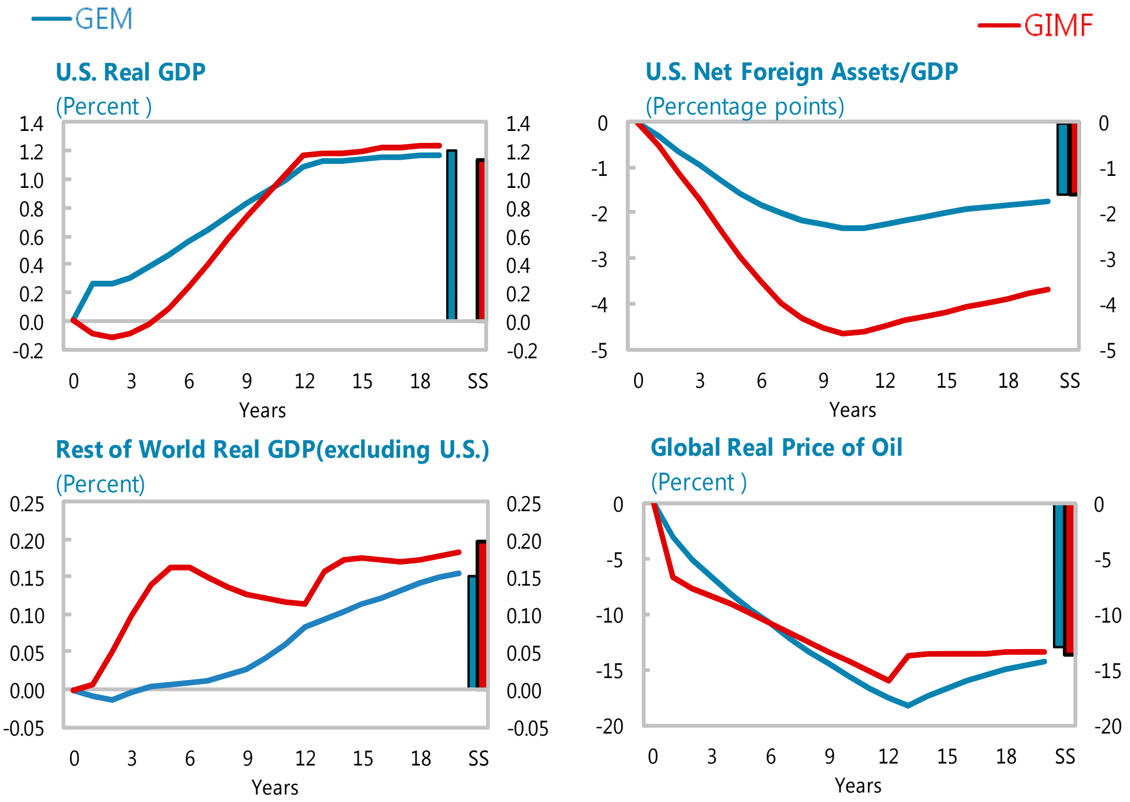
Source: Authors' calculations

With similar impacts on the global price of energy in the two models, the long-run effects on output in the United States and the rest of the world are broadly similar. However, the impact on the long-run U.S. net foreign asset position is still quite different. GIMF's finite-planning-horizon households are a more plausible characterization of behavior and the long-run change in the NFA position has an economically meaningful interpretation. Given their desired holding of assets to support their planned path for consumption, U.S. households do not want to hold all of the increase in the U.S. capital stock resulting from the permanent reduction in a key factor cost, energy. Consequently, in the long run, the U.S. NFA position declines and foreigners hold some of the increase in the U.S. capital stock.

C. Imposing the Change in GIMF's Long-Run Net Foreign Asset Position in GEM

The change in the long-run NFA position coming from the GIMF simulation in Figure 8 is thus imposed on the long-run NFA position in GEM, leading to the results of Figure 9.

Figure 9: Imposing GIMF's Long-Run Net Foreign Asset Position in GEM



Source: Authors' calculations