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New estimates of the security costs of U.S. oil consumption☆

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ABSTRACT

In recent years, the United States has become much more self-reliant in producing oil, and a newer economics literature suggests that oil demand may be more elastic and U.S. GDP may be less sensitive to world oil price shocks than was previously estimated. These developments suggest somewhat lower security costs may be associated with U.S. oil consumption. This analysis provides updated estimates of the security premiums for U.S. consumption of imported oil, U.S. consumption of domestically produced oil, and the substitution of imported oil for domestically produced oil. Estimates of the expected security costs of U.S. oil consumption are provided over the time horizon from 2015 to 2040, while taking into account projected world oil market conditions, the probabilities and sizes of world oil supply disruptions, the response of world oil prices to those supply disruptions, and the response of U.S. real GDP to those oil price shocks. The estimated oil security premiums suggest that U.S. oil security has become less of a policy concern.

1. Introduction

Nordhaus (1974) investigated the use of a tariff and other measures to reduce U.S. dependence on insecure foreign oil supplies. Landsberg et al. (1979) introduced the idea that U.S. dependence on imported oil will result in social costs that are greater than the market price paid for the oil. Dubbing the cost as the “import premium,” they estimated the cost of consuming a barrel of imported oil over a barrel of domestically produced oil. The components of this traditional oil import premium include the macroeconomic risks associated with greater exposure to world oil supply disruptions, the effect of oil price shocks on transfers abroad, and a monopsony premium—the latter being the U.S. opportunity to exercise market power in buying oil on the world market. A number of others, including the Energy Modeling Forum (1982), Bohi and Montgomery (1982a, 1982b), Broadman (1986), Bohi and Toman (1993), Parry and Darmstadter (2003), and Leiby (2008), followed by estimating the oil import premium.

In later efforts, Toman (2002), Ross (2002) and Nordhaus (2009) argue that fungibility and an integrated global world oil market mean that domestic oil is subject to the same price fluctuations as imported oil. Hence, oil security costs apply to the consumption of domestic as well as imported oil. And, according to Brown and Huntington (2013), the consumption of domestic oil instead of imported oil enhances security of supply only to the extent that the production of domestic oil increases the stability of the global oil supply.

Building on the earlier literature, Brown and Huntington (2013) identify in detail the components of oil premiums for the consumption of imported and domestic oil. For imported oil, the components include the monopsony premium, expected transfers on the marginal barrel of imported oil occurring during an oil supply disruption, the change in the expected macroeconomic losses and the change in the expected transfers on the inframarginal barrels of imported oil associated with oil supply disruptions. For domestic oil, the components include only the change in the expected macroeconomic losses and the change in the expected transfers on the inframarginal barrels of imported oil associated with oil supply disruptions.

Of these components, Brown and Huntington argue that only the changes in the expected macroeconomic losses and the changes in the expected transfers on the inframarginal barrels of imported oil should be included in oil security premiums. The consumption of additional oil imposes costs on others and will not be taken into account by those consuming the marginal barrel of oil. They see the expected transfers on the marginal barrel of imported oil occurring during a supply shock as something the purchaser can anticipate, and they see the U.S. opportunity to exercise market power in buying oil on the world market as something that is dependent on stable market conditions rather than oil supply disruptions.

Brown and Huntington (2013, 2015) provide fairly recent estimates of the oil security premiums associated with U.S. consumption of both domestic and imported oil. But, these oil security estimates rely on

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world oil market conditions and a set of parameters that are used to assess how the world oil market responds to supply disruptions and how U.S. real GDP responds to the resulting oil price shocks. Over the past few years, world oil market conditions have changed considerably (with the United States importing much less oil), new estimates of the probabilities of world oil supply disruptions have become available, and new estimates of the response of U.S. real GDP to oil supply shocks and the short-run elasticity of oil demand have become available. These developments suggest that it is time to update the estimates of the security costs of U.S. oil consumption. The new estimates of the oil security premiums suggest that U.S. oil security may have become less of an issue than it was in the past, mostly as a result of new estimates of the short-run elasticity of demand and the response of U.S. real GDP to oil price shocks.

The remainder of the paper is organized as follows. Section 2 describes the methods used to evaluate the economic costs of U.S. oil consumption. Section 3 presents estimates of the oil security premiums to assess how changes in world oil market conditions, probabilities of disruptions, and estimates of the elasticities of oil demand and the response of U.S. GDP to oil price shocks affect the measured security costs of U.S. oil consumption. Section 4 examines the elasticities underlying the estimates of the oil security premiums. Section 5 examines some of the policy implications of the differing estimates, and Section 6 offers concluding remarks and draws broader policy implications.

2. The economic cost of U.S. oil consumption

To estimate the costs of U.S. oil consumption beyond production or import costs, we follow Brown and Huntington (2013, 2015) and take a computational approach based on a simple welfare-analytic model of U.S. oil consumption (Appendix A). This approach provides four component premiums for the consumption of imported oil and two component premiums for the consumption of domestically produced oil. These individual components can be used to provide estimates of the narrow oil security premiums recommended by Brown and Huntington (2013) or the more expansive oil premiums that characterized the earlier literature.

Although oil trades at a world determined price, U.S. policy can affect oil security by differentiating between domestically produced and imported oil. Domestic oil production is politically stable, whereas Brown and Huntington (2017) find that historically unstable oil-producing countries are prominent among the marginal suppliers of non-U.S. oil.[1] The increased production of stable supplies lessens the price response to a world oil supply disruption, whereas the increased production of unstable supplies increases the size of oil supply disruptions.[2]

2.1. Components of the oil premiums

As shown in Table 1 and explained in more detail in Appendix A, only a few of the component premiums are related to oil supply disruptions and are unlikely to be taken into account in market decisions. The distinction is important because policymakers may take an expansive approach of considering the costs of oil dependence while a focus on oil security favors more narrowly conceived measures.

The monopsony premium measures the gains in the terms of trade that the United States could obtain by restricting its oil imports, or more accurately, the increased cost that U.S. consumers will face as the result of the world oil price rising as the United States imports one more barrel of oil. Because the premium is for normal market conditions, rather than a cost that arises from expected oil supply disruptions,

Table 1
Oil security premium concepts.

	Imports	Domestic
Monopsony premium	Not a security issue A pecuniary externality	Not applicable
Expected price shock for purchaser of marginal imports	A security issue Not an externality	Not applicable
Change in expected transfers for inframarginal oil imports	A security issue A pecuniary externality	A security issue A pecuniary externality
Change in expected GDP losses	A security issue An externality	A security issue An externality
Environmental externalities	Externalities, but not a security issue	Externalities, but not a security issue

Brown and Huntington (2013) exclude the monopsony premium from their oil security measures. They also note the monopsony premium is what economists consider a pecuniary externality. It is a transfer from U.S. consumers to world oil producers that nets out worldwide, even though it may be considered in setting U.S. policy.

Although the expected price shock for the purchaser of the marginal barrel of imported oil depends on expected oil supply disruptions, Brown and Huntington exclude it from their oil security premiums because the consumer who purchases oil or oil-using equipment is aware (or should be aware) of the possibility of price shocks originating from world oil supply disruptions.[3] In contrast, Brown and Huntington include the expected transfers on inframarginal oil imports and the change in expected GDP losses in their oil security premiums. In both cases, U.S. consumption of additional oil imposes alters the costs that other U.S. consumers will bear during an oil supply disruption and will not be taken into account by those consuming the marginal barrel of oil.[4]

2.2. Aggregate measures of the oil premiums

As shown in Table 2, the six individual components provide the basis for calculating four additional components and six aggregate measures of the oil premiums. As shown in the table, four component premiums for the displacement of domestic oil with imported oil for domestic oil can be obtained by differencing the component premiums for the consumption of imported oil and domestic oil. The six aggregate measures include oil-security premiums for the consumption of imported oil, for the consumption of domestic oil, and for the displacement of domestic oil with imported oil. They also include traditional oil premiums for the consumption of imported oil, for the consumption of domestic oil, and for the displacement of domestic oil with imported oil.

According to Leiby (2016), current U.S. policy focuses on the oil security premium for U.S. consumption of imported oil, which includes GDP losses and transfers on the inframarginal barrel of imported oil. This premium evaluates the external security costs associated with a marginal increase in the U.S. consumption of imported oil. The oil security premium for U.S. consumption of domestic oil evaluates the external security cost associated with a marginal increase in the consumption of domestic oil. The oil security premium for imported vs.

[1] It should be noted that many oil producers outside the United States are also stable.

[2] As in Beccue and Huntington (2005, 2016), EIA (2017) and Huntington (forthcoming), oil supply disruptions refer to the geopolitical, military, and terrorist causes of foreign oil supply disruptions. They exclude the effects of natural supply disruptions brought about by such events as hurricanes or other severe weather conditions.

[3] In practice, consumers may not fully understand the probabilities of future oil supply disruptions and the accompanying price shocks, which could result in losses that are not fully considered in the decision process.

[4] Like the monopsony premium, the expected transfers on inframarginal oil imports are a pecuniary externality because the increased prices that U.S. consumers pay for imported oil during an oil supply disruption are transfers to oil-exporting countries that net out worldwide.

Table 2
Oil premium measures.

		Imports	Domestic	Imports vs. Domestic
A.	Monopsony premium	Computed as described in text	Not applicable	A Imports minus A domestic
B.	Expected price shock for purchaser of marginal imports	Computed as described in text	Not applicable	B Imports minus B domestic
C.	Change in expected transfers for inframarginal oil imports	Computed as described in text	Computed as described in text	C Imports minus C domestic
D.	Change in expected GDP losses	Computed as described in text	Computed as described in text	D Imports minus D domestic
Oil security premiums C + D		C + D imports	C + D domestic	C + D Imports minus domestic
Traditional oil premiums A + B + C + D		A + B + C + D imports	A + B + C + D domestic	A + B + C + D Imports minus domestic

Note: The traditional oil import premium is the sum of the differences between the premiums for imported and domestic oil.

domestic oil evaluates the external security cost associated with the substitution of a barrel of imported oil for a barrel of domestic oil.

The traditional premiums also include the monopsony premium and the expected transfer on the marginal barrel of imported oil consumption. Although neither is included in evaluating oil security, both might be taken into account by policymakers who are evaluating the domestic costs of oil dependence.[5]

3. Quantifying the security costs of U.S. oil consumption

The computational methods described in Appendix B are used with the world oil market conditions that prevailed in 2014 and those projected by the U.S. Energy Information Administration (EIA) (2012, 2016) to estimate the individual components of the oil security premiums. For each year, the components are calculated taking into account world oil market conditions, the probability and sizes of disruptions, short-run demand and supply elasticities and the response of U.S. real GDP to oil price shocks resulting from oil supply disruptions. With these components, estimated oil security premiums for the consumption of imported oil, the consumption of domestic oil and the substitution of imported oil for domestic oil are derived.

The analysis examines the implications of four different sets of assumptions about world oil market conditions, the probabilities and sizes of disruptions, demand and supply elasticities, and the response of U.S. real GDP to oil price shocks. The first part examines how updated world oil market conditions and new estimates of the probabilities of disruptions affect the estimated oil security premiums. The second part examines how newer estimates of the short-run elasticity of demand and the response of U.S. real GDP oil price shocks affect the estimated oil security premiums. The third and fourth parts examine how the estimated premiums evolve from 2015 to 2040.

3.1. From old to new parameter values

Updating the estimates of the oil security premiums to those using the most current information requires three steps and yields three sets of oil security premiums. The first step is to update the underlying evaluation scenario and of the sizes and probabilities of disruptions, but to use the estimates of the short-run elasticity of demand and the elasticity of GDP with respect to oil prices from the older literature. This effort yields estimated security premiums based on older parameters values taken from the literature and is identified as PVL-O. The second step is to use newer estimates of the short-run elasticity of demand and the response of U.S. real GDP to oil price shocks to estimate the oil security premiums identified as PVL-N. The third step is to combine the older and newer estimates of the short-run elasticity of demand and of the elasticity of GDP with respect to oil price shocks to estimate the oil security premiums identified as PVL-C.

Taken together PVL-O and PVL-N yield good coverage of the estimated elasticities from the economics literature. PVL-O represents the older literature with higher oil security premiums that result from less elastic demand and a stronger response of U.S. GDP to world oil price shocks. PVL-N represents the newer literature with lower oil security premiums that result from more elastic demand and a weaker response of U.S. GDP to world oil price shocks.

Simply dividing the estimates of the elasticities into old and new and then computing the oil security premiums, however, downplays the uncertainty inherent in the estimated oil security premiums. PVL-C combines the older and newer literature, and it allows for a range of estimates that may better capture the uncertainty involved in calculating oil security premiums. In doing so, it brings together insights from both the older and newer literature about how world oil markets and the U.S. economy might respond to future oil supply disruptions.

3.1.1. World oil market conditions

Brown and Huntington (2015) use the projected world oil market conditions in the *2012 AEO* (EIA, 2012) as the basis for their estimation of the oil security premiums. Quantifying the difference on the oil security premiums between the oil market conditions that were projected in the *2012 AEO*, today's market realities and the *2016 AEO* provides insight into how changing oil market conditions affect the computation of these premiums. As shown in Table 3, actual world oil market conditions in 2014 were substantially different than were projected as the 2013–14 average in the *2012 AEO*. In 2014, world oil prices were somewhat lower, world oil consumption was higher, non-U.S. oil consumption was higher, non-U.S. oil production was lower, U.S. oil consumption was slightly higher, U.S. oil production was higher, U.S. oil imports were considerably lower and U.S. real GDP was higher.

3.1.2. Disruption probabilities

The oil security premiums are calculated on the basis of the probabilities and sizes of the disruptions. Using world oil market conditions and parameters describing the market response, outcomes are generated for each disruption size and the outcomes are weighted by the probabilities of each size of disruption (as explained in Appendix B).

Beccue and Huntington (2005, 2016) provide probabilities and sizes of expected world oil supply disruptions. Beccue and Huntington use a structured survey of experts to evaluate the likelihood of foreign oil supply disruptions over a 10-year period. Although severe weather and other natural phenomena could result in significant disruptions, their study focused on geopolitical, military, and terrorist causes of disruptions abroad. The expected disruptions are the net oil supply shock after all surplus capacity available to the market has been used.

The Beccue and Huntington probabilities are converted to the annual values shown in Table 4.[6] The underlying world oil market conditions for Beccue and Huntington (2005) match the average 2013–14 world oil market conditions as projected in the *2012 AEO*, and the expected annual supply disruptions range from 0 to 17 million barrels per day (in 1 million barrel per day increments) against non-U.S.

[5] Estimates of the monopsony premium and the expected transfers on the marginal barrel of imported oil and the traditional oil premiums are found in Appendix C.

[6] Beccue and Huntington (2005, 2016) provide a probability for each size disruption over a decade (φ_d), with $1 - \varphi_d$ representing the probability of no disruption. If the expected instability over the decade is equally distributed across each of the 10 years, the probability of a disruption in any given year (φ_a) is $\varphi_a = 1 - (1 - \varphi_d)^{1/10}$.

Table 3
World oil market conditions and U.S. GDP.
Sources: U.S. Energy Information Administration; U.S. Bureau of Economic Analysis.

	Projections for 2013–14[1]	2014 actual
World oil price (2015 U.S. Dollars per barrel)	$116.62	$100.04
World oil consumption (million barrels per day)	90	92.79
Non-U.S. oil consumption (million barrels per day)	69	73.63
Non-U.S. oil production (million barrels per day)	80	78.78
U.S. Oil consumption (million barrels per day)	19	19.16
U.S. Oil production (million barrels per day)	10	14.01
U.S. Oil Imports (million barrels per day)	9	5.15
U.S. GDP (2015 U.S. Dollars)	$16.954 trillion	$17.580 trillion

Author's calculations.
[1] EIA (2012).

Table 4
Sizes and annual probabilities of disruptions.
Sources: Adapted from Beccue and Huntington (2005, 2016).

Disruption size (million barrels per day)	Annual probability	
	2005 estimates	2016 estimates
0	0.843908554	0.899581023
1	0.030919163	0.003688530
2	0.032529155	0.012149011
3	0.045339487	0.015030933
4	0.002158576	0.016455510
5	0.007761138	0.009781145
6	0.010281493	0.008760577
7	0.010911735	0.010478909
8	0.007640165	0.008013227
9	0.001080596	0.004992078
10	0.001564854	0.002588981
11	0.001180577	0.003115885
12	0.001732513	0.002128716
13	0.000830936	0.000866718
14	0.000511190	0.000882371
15	0.000986074	0.000464093
16	0.000119553	0.000527113
17	0.000132331	0.000134663
18	–	0.000106642
19	–	0.000124019
20	–	0.000024215
21	–	0.000105641

Note: 2005 estimates are based on non-U.S. oil production of 80 million barrels per day. 2016 estimates are based on non-U.S. oil production of 78.78 million barrels per day.

production of 80 million barrel per day. The underlying world oil market conditions for Beccue and Huntington (2016) are the world oil market conditions that prevailed in 2014, and the expected annual supply disruptions range from 0 to 21 million barrels (in 1 million barrel per day increments) against non-U.S. production of 78.78 million barrels per day. For other years, the size of these disruptions is scaled according to non-U.S. oil production.

As shown in the table, the two sets of estimated disruption probabilities and sizes are somewhat different. The 2016 disruption estimates are based on smaller non-U.S. production. The 2016 estimates also show smaller probabilities of small disruptions, but greater probabilities of medium and large disruptions. Overall, the probability of a disruption is lower.

3.1.3. Price, income and GDP elasticities

Price and income elasticities and elasticities of GDP with respect to oil price shocks are used to compute the oil security premiums. The older values shown in Table 5 represent the Brown and Huntington (2013) interpretation of representative values from the literature. Their sources include the Atkins and Jazayeri (2004) and Dahl (2010a, 2010b) surveys of oil demand elasticities, the Hickman et al. (1987) review of participating models in an Energy Modeling Forum study, the Jones et al. (2004) survey of the elasticities of GDP with respect to oil price shocks, as well as Krichene (2002), Cooper (2003), Huntington (2005), Leiby (2008), Hamilton (2009), Kilian (2009), Smith (2009), Blanchard and Gali (2010), and Balke et al. (2010).

The newer values of the short-run demand elasticity are the author's adaptation of work by Davis and Kilian (2011), Kilian and Murphy (2014) and Coglianese et al. (2015). The newer values of the elasticity of GDP with respect to oil price shocks are the author's interpretation of work by Kilian (2009), Herrera and Pesavento (2009), Balke et al. (2010), Blanchard and Gali (2010), Kilian and Vigfusson (2011a, 2011b), Kilian and Murphy (2014), Baumeister and Hamilton (2015) and Balke and Brown (2017). According to the newer research, demand is more elastic in the short-run, suggesting that oil users respond more flexibly to changes in oil prices than is indicated by the older literature. Similarly, the newer macroeconomic research shows the economy

Table 5
Price, income and GDP elasticities.
Sources: Brown and Huntington (2013) and Author's updates.

Type	Older values	Newer values	Combined values
Short-run price	0.05	0.05	0.05
Elasticity of supply	0.025–0.075	0.025–0.075	0.025–0.075
Short-run price	−0.055	−0.0175	−0.055
Elasticity of demand	−0.02 to −0.09	−0.1 to − 0.25	−0.02 to −0.25
Income elasticity of demand	0.70	0.70	0.70
	0.55–0.75	0.55–0.75	0.55–0.75
Elasticity of U.S. GDP with respect to oil price shocks	−0.044	−0.018	−0.028
	−0.012 to −0.078	−0.006 to − 0.029	−0.006 to −0.051
Long-run price	0.4	0.4	0.4
Elasticity of supply	0.35–0.45	0.35–0.45	0.35–0.45
Long-run price	−0.4	−0.4	−0.4
Elasticity of demand	−0.35 to −0.45	−0.35 to − 0.45	−0.35 to −0.45

Table 6
Response of U.S. real GDP to oil price shocks.
Sources: Brown and Huntington (2013) and Author's updates.

Ref.	Elasticity
Econometric studies (Jones et al., 2004)	−0.012 to −0.12
Leiby (2008) Described range	−0.01 to −0.08
Energy Modeling Forum (Hickman et al., 1987)	−0.02 to −0.075
U.S. Department of Energy (Jones et al., 2004)	−0.025 to −0.055
Leiby (2008) Analysis range	−0.035 −0.010 to −0.054
Brown and Huntington (2013) Analysis range	−0.044 −0.012 to −0.078
Newer estimates	−0.018 −0.006 to −0.029
Evolutionary estimates	−0.028 −0.006 to −0.051

responds more flexibly to oil price shocks than the older literature found and there is less economic impact. The compromise values are obtained by combining the older and newer estimates.

Given that the assumed oil market scenario and oil supply disruptions are the same for PVL-O, PVL-N and PVL-C, the elasticities take a central role in determining the differences in the oil security premiums across the various models. The more elastic are demand and supply, the smaller will be the price shocks arising from oil supply disruptions. The less responsive is real GDP with respect to oil price shocks, the smaller will be the GDP losses resulting from a given oil price shock. Lower values of the GDP elasticities also strengthen the overall price shock.

3.1.3.1. A closer look at the short-run demand elasticities. The older estimates of the short-run elasticities of demand show world oil consumption to be quite unresponsive to prices, suggesting that there is relatively little flexibility in oil consumption, with Brown and Huntington (2013, 2015) using −0.055 in a range of −0.02 to −0.09 to represent this literature. More recent econometric studies of U.S. crude oil and refined product demand, such as Davis and Kilian (2011), Kilian and Murphy (2014) and Coglianese et al. (2015), find that U.S. oil demand is more elastic in the short run, with the author of the present work using a value of −0.175 in a range of −0.10 to −0.25 to represent the newer literature. Although these values are still fairly inelastic, they show considerably more flexibility on the part of oil consumers. With these more elastic values, the effect of any given oil supply disruption on world oil prices is considerably less than with the older elasticities.

Some of the recent econometric research uses cross-state data on tax changes to estimate gasoline demand, which yields a state-level response to changes in gasoline taxes. Such exercises are informative, but may not reflect how world oil consumption responds to rising oil prices. Huntington (2017) explains that estimating U.S. gasoline demand with cross-state data likely yields demand elasticities that are substantially more elastic than are appropriate to represent the world response to an oil supply disruption. Using a simultaneous equation model of the world oil and natural gas markets, Krichene (2002) concludes, "The demand for crude oil has a low short run price elasticity: −0.05 in 1918–2004, −0.05 in 1918–73, and −0.003 in 1974–2004 … [and] crude oil demand is highly price-inelastic in the short run, as energy consumption is essentially determined by fixed capital." Askari and Krichene (2010) estimate short-run demand and supply elasticities of −0.02 and 0.02, respectively.

Hamilton (2009) and Smith (2009) also provide compelling narratives about the movements in oil prices using very low elasticities of world oil demand. Consider Hamilton's analysis of the 2004–2008 world oil market experience. Using the more elastic demand values would make it impossible to track the path of world oil consumption with the actual prices and world GDP that prevailed at the time. In addition, consider the late-1973 oil supply disruption that resulted in a 1.4% decrease in world crude oil supplies from 1973 to 1974. World oil prices rose by 115.5%, which—all else held equal—implies an elasticity of world oil demand of − 0.012, and a more inelastic value if you consider the contraction in world economic activity over that two-year period.

Overall, it is likely better to extend the range of demand elasticities used to estimate oil security premiums than to rely exclusively on the estimates from the newer literature. A compromise approach is to combine the less elastic values of the older literature with the more elastic values of the newer literature, keeping the old mid- and lower values while extending the upper value to reflect the newer estimates, which yields a mid-value of − 0.055 in a range of − 0.02 to − 0.25. The combined estimates more heavily weight the older literature, reflecting both how few articles comprise the newer literature and concerns that the newer literature may not reflect how the world oil market would respond to an oil supply disruption.

3.1.3.2. The response of U.S. real GDP to oil price shocks. As shown in Table 6, estimated elasticities of GDP with respect to oil price shocks (originating from an oil supply disruption) have a wide range of values, −0.012 to −0.12 as described by Jones et al. (2004). Leiby (2008) describes a narrower range of elasticity values at −0.01 to −0.08. Brown and Huntington (2013) use a mid-value of −0.044 in a slightly narrower range of −0.012 to −0.078, and Leiby uses a mid-value of −0.035 in a still narrower range of −0.01 to −0.054. The more recent empirical research—such as Kilian (2009), Herrera and Pesavento (2009), Balke et al. (2010), Blanchard and Gali (2010), Kilian and Vigfusson (2011a, 2011b), Kilian and Murphy (2014), Baumeister and Hamilton (2015), and Balke and Brown (2017)—suggests a much weaker GDP response, with a mid-value of −0.018 in a range of −0.006 to −0.029.[7]

The weaker response of GDP to oil price shocks may owe to improved monetary policy, the economy better adjusting to oil supply disruptions, improved modeling techniques, and/or the lack of major oil supply disruptions in the past decade. Huntington (forthcoming) cautions that the world has not seen a major oil supply disruption since 2003, which raises the possibility that research that focuses on relatively recent data is likely to give considerable weight to an era in which the events of interest have not occurred.

Hence, it is likely premature to rely heavily on the least elastic values of GDP with respect to oil price shocks. A compromise approach is to combine the older and newer estimates to obtain a mid-value of −0.028 in a range of −0.006 to −0.051, which represents the uncertainty about the effects of oil price shocks on economic activity. The low and mid-values of the combined estimates reflect the lower and upper estimates from the newer literature, while the upper value creates a near symmetric distribution around the combined mid-value. These combined estimates more heavily weight the newer literature, reflecting both the large number of articles in the newer literature and the well-developed explanations about why the estimates are lower.

[7] A meta-analysis by Oladosu et al. (2017) finds a somewhat higher mid-value of −0.024 in a wider range of +0.005 to −0.035. Similarly, Herrera (2016) finds a mid-value of −0.0274 in a range of −0.0127 to −0.0623, but her estimates of the GDP response also find demand and supply are much more elastic than is typical of the literature on demand and supply elasticities. Combining her elasticities with expected oil supply disruptions and world oil market conditions yields a modest effect on world oil prices and U.S. real GDP.

Table 7
Components of the oil security premiums, 2014 (2015 U.S. Dollars per barrel).
Source: Model estimates.

Model	Change in expected GDP loss		Change in expected transfers on inframarginal oil imports	
	Marginal consumption of imported oil	Marginal consumption of domestic oil	Marginal consumption of imported oil	Marginal consumption of domestic oil
Brown-Huntington (2015)	$5.31 $1.12–$15.42	$4.06 $0.86–$11.85	$0.11 $0.07–$0.28	− $0.89 − $0.60 to − $2.25
PVL-O	$5.21 $1.10–$15.07	$3.96 $0.84–$11.53	$0.06 $0.04–$0.16	− $0.35 − $0.24 to − $0.89
PVL-N	$1.23 $0.58–$3.39	$0.93 $0.44–$2.57	$0.03 $0.02–$0.06	− $0.15 − $0.10 to − $0.33
PVL-C	$3.63 $0.30–$11.75	$2.75 $0.22–$8.97	$0.07 $0.02–$0.24	− $0.41 − $0.10 to − $1.35

3.2. Oil security premiums, from Brown-Huntington to newer measures

Using the methods, oil market conditions, the probability and sizes of disruptions and the elasticities described above, we develop four sets of estimated oil premiums. These include a replication of Brown-Huntington (2015), PVL-O which uses updated world oil market conditions and probabilities and sizes of disruptions, PVL-N which uses the newer estimates of the short-run elasticity of demand and the response of GDP to oil price shocks, and PVL-C which combines the older and newer estimates of the short-run elasticity of demand and the response of GDP to oil price shocks.

As shown in Table 7, the GDP effects are greater for the consumption of imported oil than domestic oil. The difference arises because increased oil imports increase the size of the expected price shock because greater imports increase the size of potential disruptions in unstable regions of the world. In contrast, increased domestic oil production weakens the expected price response because greater U.S. oil production increases the share of the oil market coming from stable supplies. Similarly, increased consumption of imported oil increases the transfers on the inframarginal purchases of imported oil, yielding a small expected cost. Increased consumption of domestic oil reduces the transfers on the inframarginal purchases of imported oil, yielding a small expected gain (shown as a negative loss in the table).

As shown in the table, the individual components of the oil premiums generally show smaller changes as we move from the Brown-Huntington assumptions to PVL-O. For PVL-O, a slightly larger GDP boosts the expected dollar value of the GDP loss. That effect is more than offset by increased U.S. oil production and lower oil prices, which yield a smaller expected oil price shock than for the Brown-Huntington assumptions, resulting in smaller expected GDP losses and smaller expected transfers on inframarginal oil imports. The updated probabilities and sizes of disruptions also slightly reduce the estimates.

Table 8
Aggregate oil security premiums, 2014 (2015 U.S. Dollars per barrel).
Source: Model estimates.

Model	Consumption of imported oil	Consumption of domestic oil	Imported vs. domestic oil
Brown-Huntington (2015)	$5.43 $1.20–$15.70	$3.17 $0.26–$9.60	$2.26 $0.94–$6.10
PVL-O	$5.28 $1.15–$15.22	$3.60 $0.60–$10.63	$1.68 $0.55–$4.59
PVL-N	$1.26 $0.60–$3.45	$0.78 $0.34–$2.24	$0.48 $0.26–$1.21
PVL-C	$3.70 $0.31–$11.99	$2.34 $0.12–$7.62	$1.36 $0.19–$4.37

For PVL-N, the more elastic demand and weaker GDP responses combine to yield smaller expected GDP losses and expected transfers on inframarginal oil imports than are found with PVL-O. For PVL-C, the wider range of demand elasticities and U.S. real GDP responses to oil price shocks combine to yield expected GDP losses that are between those found for PVL-O and PVL-N. The expected transfers are somewhat greater for PVL-C than PVL-O because the less elastic GDP response leads to greater expected price shocks.

As shown in Table 8, the aggregate oil security premiums that result from combining the individual components generally decrease from the Brown-Huntington assumptions to PVL-O to PVL-C and then PVL-N. The exception is the oil security premium for the consumption of domestic oil, which increases as we move from the Brown-Huntington assumptions to PVL-O. The increased aggregate results from combining a smaller expected GDP loss with a smaller expected gain in transfers on the inframarginal purchases of imported oil.

3.3. Components of the oil security premiums 2015–2040

As described above, four components are used to compute the oil security premiums. The two bigger components are the change in expected GDP losses that result from a marginal increase in the consumption of imported or domestic oil. The two smaller components are the change in the expected transfers on the inframarginal consumption of imported oil that result from a marginal increase in the consumption of imported or domestic oil.

These four components are estimated for the 2015–2040 time horizon using the EIA's (2016) projections of world oil market conditions. Over this 25-year time period, world oil consumption is projected to increase from 93.90 million barrels per day to 122.44 million barrels per day. U.S. oil consumption is projected to rise from 19.42 million barrels per day to 20.14 million barrels per day, with U.S. oil production rising from 14.95 million barrels per day to 18.62 million barrels per day and U.S. oil imports falling from 4.47 million barrels per day to 1.52 million barrels per day. Over the same time horizon, non-U.S. oil consumption is projected to rise from 74.48 million barrels per day to 102.00 million barrels per day. The world oil price is projected to dip from $52.32 per barrel after 2015 before rising to $136.21 per barrel in 2040. U.S. real GDP is projected to rise at about a 2.23% annual rate from $17.983 trillion in 2015 to $31.235 trillion in 2040.[8]

3.3.1. Change in the expected GDP loss from a marginal increase in the consumption of imported oil

As shown in Fig. 1, the change in the expected GDP loss from a marginal increase in the consumption of imported oil increases from

[8] All reported values are in 2015 dollars.

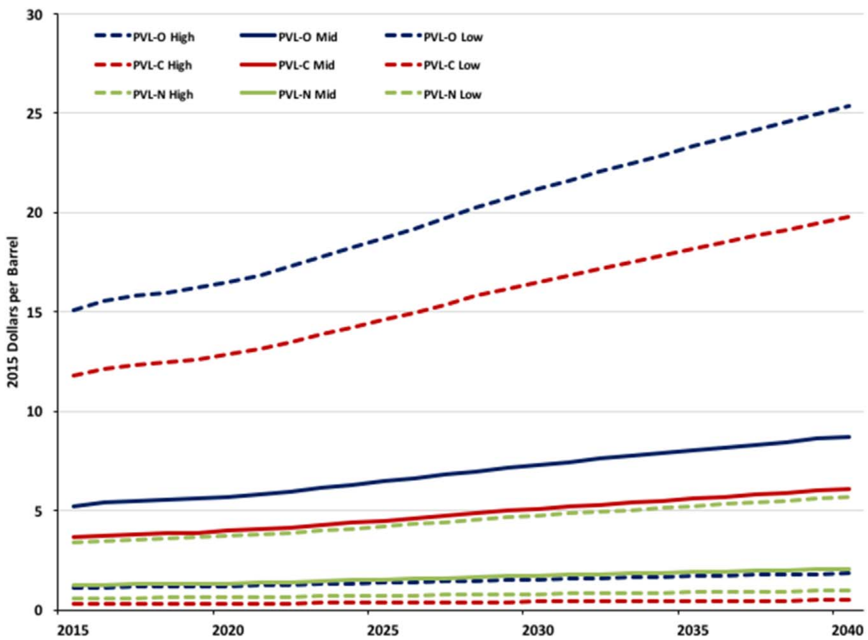

Fig. 1. Change in expected GDP loss for marginal consumption of imported Oil.

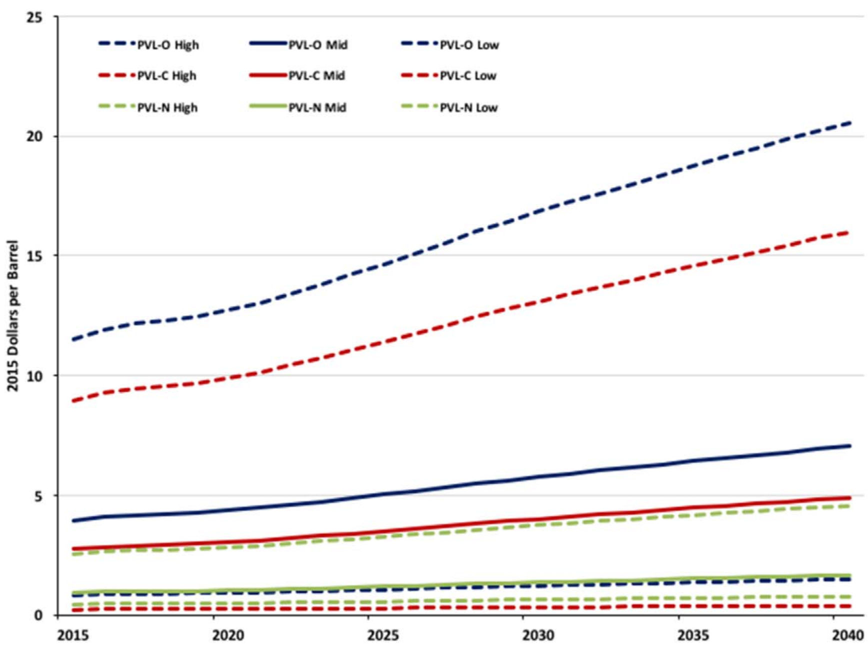

Fig. 2. Change in expected GDP loss for marginal consumption of domestic oil.

2015 to 2040. The gains are largely driven by projected gains in U.S. real GDP and non-U.S. oil production. As shown in the figure, PVL-O finds the premium rising from a mid-value of $5.23 per barrel (in a range of $1.11–$15.09) in 2015 to a mid-value of $8.74 per barrel (in a range of $1.85–$25.35) in 2040. Under PVL-C, the premium rises from a mid-value of $3.64 per barrel (in a range of $0.30–$11.77) in 2015 to a mid-value of $6.09 per barrel (in a range of $0.50–$19.76) in 2040. Under PVL-N, the premium rises from a mid-value of $1.23 per barrel (in a range of $0.58–$3.40) in 2015 to a mid-value of $2.07 per barrel (in a range of $0.97–$5.68) in 2040.

3.3.2. Change in the expected GDP loss from a marginal increase in the consumption of domestic oil

As shown in Fig. 2, the change in the expected GDP loss from a marginal increase in the consumption of domestic oil increases from 2015 to 2040. The gains are largely driven by projected gains in U.S. real GDP and non-U.S. oil production. As shown in the figure, PVL-O finds the premium rising from a mid-value of $3.95 per barrel (in a range of $0.83–$11.51) in 2015 to a mid-value of $7.04 per barrel (in a range of $1.49–$20.55) in 2040. Under PVL-C, the premium rises from a mid-value of $2.75 per barrel (in a range of $0.22–$8.96) in 2015 to mid-value of $4.90 per barrel (in a range of $0.40–$15.99) in 2040. Under PVL-N, the premium rises from a mid-value of $0.93 per barrel (in a range of $0.44–$2.57) in 2015 to mid-value of $1.66 per barrel (in a range of $0.78–$4.57) in 2040.

3.3.3. Change in the expected transfers on inframarginal oil imports from a marginal increase in the consumption of imported oil

As shown in Fig. 3, the change in the expected transfers on the consumption of inframarginal imports from a marginal increase in the consumption of imported oil decreases from 2015 to 2040. Rising oil prices play a role in the estimated value of the change in expected

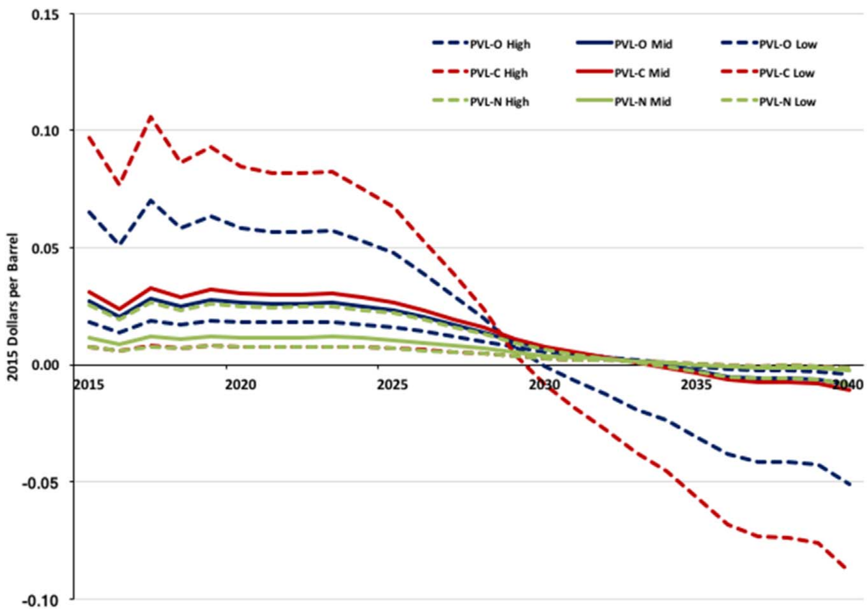

Fig. 3. Change in expected transfers on inframarginal oil imports for marginal consumption of imported oil.

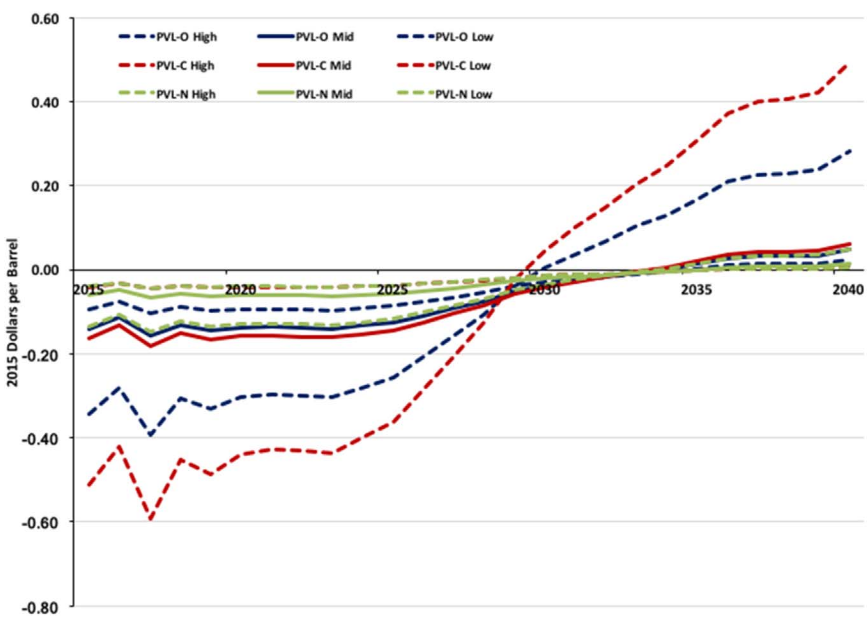

Fig. 4. Change in expected transfers on inframarginal oil imports for marginal consumption of domestic oil.

transfers on the consumption of inframarginal imports, but the value declines as U.S. imports are reduced. It turns negative when U.S. oil imports are reduced sufficiently so that the larger oil supply disruptions would result in world oil prices rising enough that the United States would export oil.

As shown in the figure, PVL-O finds the premium falling from a mid-value of $0.027 per barrel (in a range of $0.018–$0.065) in 2015 to a mid-value of -$0.009 per barrel (in a range of -$0.004 to -$0.051) in 2040. Under PVL-C, the premium falls from a mid-value of -$0.031 per barrel (in a range of -$0.008 to -$0.097) in 2015 to a mid-value of -$0.011 per barrel (in a range of -$0.001 to -$0.089) in 2040. Under PVL-N, the premium falls from a mid-value of $0.012 per barrel (in a range of $0.008–$0.025) in 2015 to a mid-value of -$0.002 per barrel (in a range of -$0.001 to -$0.009) in 2040.

3.3.4. Change in the expected transfers on inframarginal oil imports from a marginal increase in the consumption of domestic oil

As shown in Fig. 4, the change in the expected transfers on the consumption of inframarginal imports from a marginal increase in the consumption of domestic oil starts negative and increases from 2015 to 2040. Rising oil prices play a role in the estimated value of the change in expected transfers on the consumption of inframarginal imports, but the value also rises as U.S. imports are reduced. It turns positive when U.S. oil imports are reduced sufficiently so that the larger oil supply disruptions would result in world oil prices rising enough that the United States would export oil.

As shown in the figure, PVL-O finds the premium rising from a mid-value of -$0.14 per barrel (in a range of -$0.10 to -$0.34) in 2015 to a mid-value of $0.05 per barrel (in a range of $0.02–$0.28) in 2040. Under PVL-C, the premium rises from a mid-value of -$0.16 per barrel (in a range of -$0.04 to -$0.51) in 2015 to mid-value of $0.06 per barrel (in a range of $0.01–$0.49) in 2040. Under PVL-N, the premium rises from a mid-value of -$0.06 per barrel (in a range of -$0.04 to -$0.13) in 2015 to mid-value of $0.01 per barrel (in a range of $0.01–$0.05) in 2040.

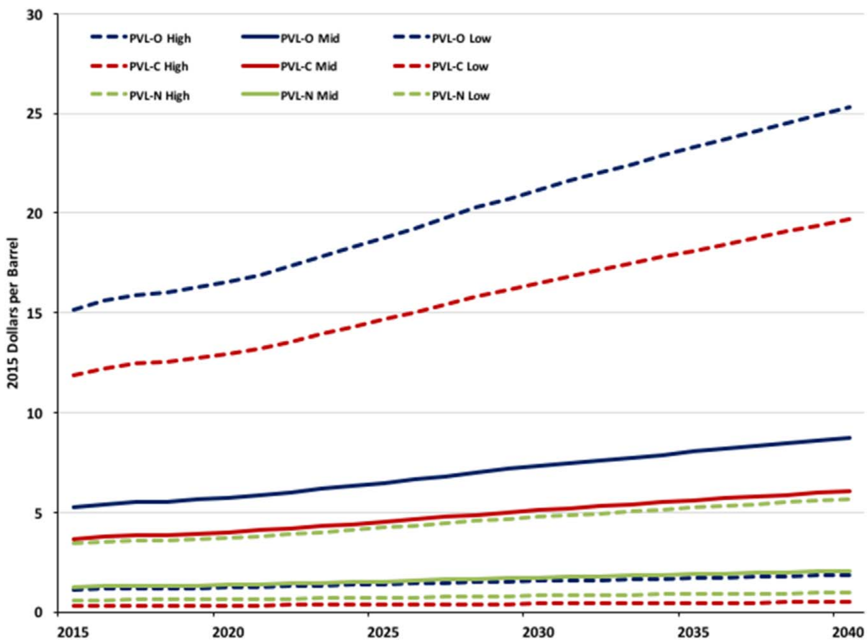

Fig. 5. Oil security premiums for the marginal consumption of imported oil.

3.4. Aggregate oil security premiums 2015–2040

Estimates of the individual components are used to develop oil security premiums from 2015 to 2040. These premiums cover the external security costs of consumption of imported oil, the consumption of domestic oil and the substitution of imported oil for domestic oil. These premiums rise from 2015 to 2040, driven by projected gains in U.S. real GDP, the world oil price and non-U.S. production.

3.4.1. Oil security premiums for the consumption of imported oil

As shown in Fig. 5, the oil security premium for U.S. consumption of imported oil increases from 2015 to 2040. The gains primarily reflect changes in expected GDP losses because the change in expected transfers on inframarginal consumption of imported oil are quite small. As shown in the figure, PVL-O finds the premium rising from a mid-value of $5.25 per barrel (in a range of $1.12–$15.16) in 2015 to a mid-value of $8.73 per barrel (in a range of $1.85–$25.30) in 2040. Under PVL-C, the premium rises from a mid-value of $3.67 per barrel (in a range of $0.30–$11.87) in 2015 to a mid-value of $6.08 per barrel (in a range of $0.49–$19.67) in 2040. Under PVL-N, the premium rises from a mid-value of $1.25 per barrel (in a range of $0.59–$3.42) in 2015 to a mid-value of $2.06 per barrel (in a range of $0.97–$5.68) in 2040.

For PVL-O, the mid-estimate of the oil security premium for U.S. consumption of imported oil averages $6.92 per barrel from 2015 to 2040 (7.2% of the average world oil price over the same time period) in a range of $1.47–$20.03 per barrel. For PVL-C, the mid-estimate averages $4.83 per barrel from 2015 to 2040 (5.0% of the average world oil price over the same time period) in a range of $0.40–$15.60 per barrel. For PVL-N, the mid-estimate averages $1.64 per barrel from 2015 to 2040 (1.7% of the average world oil price over the same time period) in a range of $0.77–$4.50 per barrel.

3.4.2. Oil security premiums for the consumption of domestic oil

As shown in Fig. 6, the oil security premium for U.S. consumption of

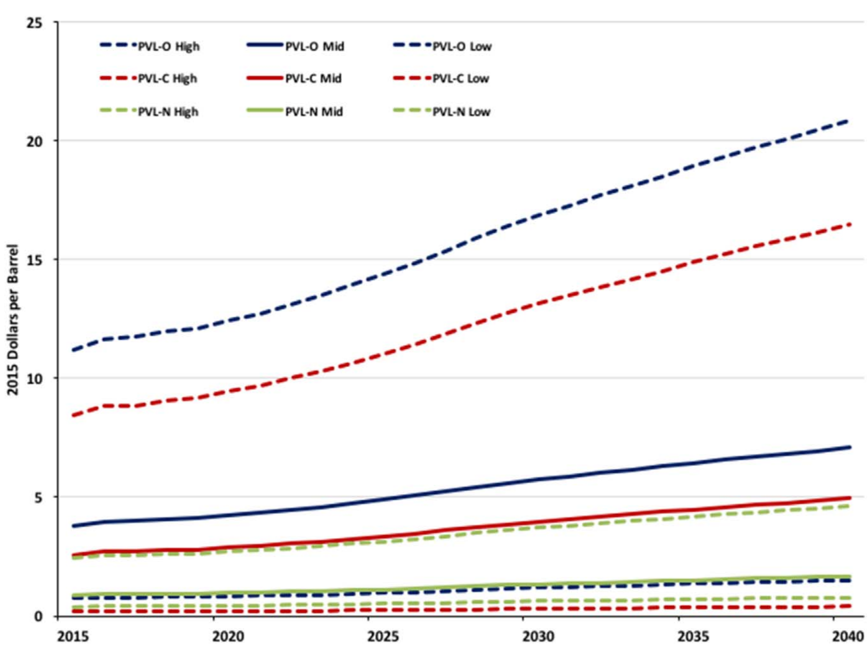

Fig. 6. Oil security premiums for the marginal consumption of domestic oil.

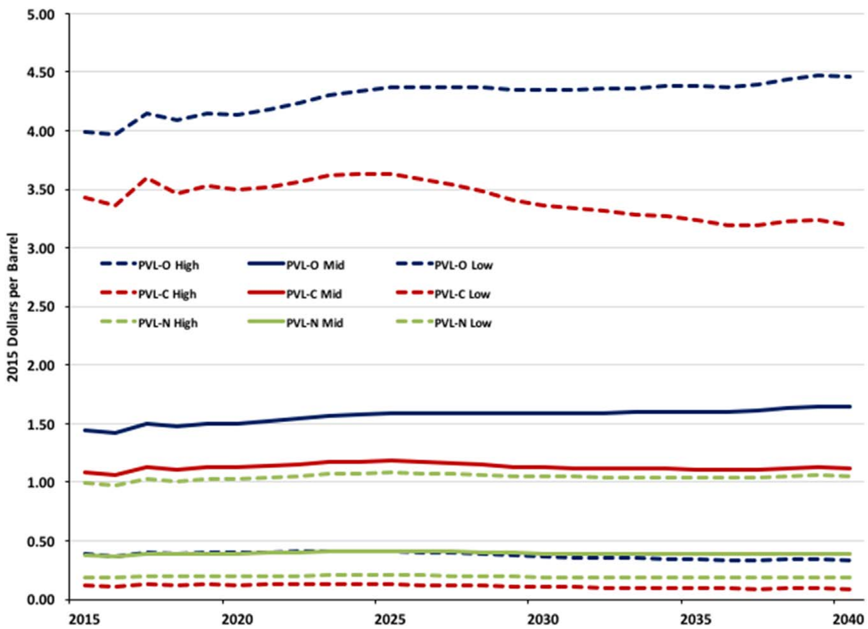

Fig. 7. Oil security premiums for imported vs. domestic oil.

domestic oil also increases from 2015 to 2040. The gains primarily reflect changes in expected GDP losses because the change in expected transfers on inframarginal consumption of imported oil are quite small. As shown in the figure, PVL-O finds the premium rising from a mid-value of $3.81 per barrel (in a range of $0.74–$11.17) in 2015 to a mid-value of $7.09 per barrel (in a range of $1.51–$20.84) in 2040. Under PVL-C, the premium rises from a mid-value of $2.59 per barrel (in a range of $0.18–$8.45) in 2015 to a mid-value of $4.96 per barrel (in a range of $0.40–$16.48) in 2040. Under PVL-N, the premium rises from a mid-value of $0.87 per barrel (in a range of $0.40–$2.43) in 2015 to a mid-value of $1.67 per barrel (in a range of $0.79–$4.62) in 2040.

For PVL-O, the mid-estimate of the oil security premium for U.S. consumption of domestic oil averages $5.36 per barrel from 2015 to 2040 (5.6% of the average world oil price over the same time period) in a range of $1.10–$15.73. For PVL-C, the mid-estimate is $3.70 per barrel from 2015 to 2040 (3.9% of the average world oil price over the same time period) in a range of $0.29–$12.21. For PVL-N, the mid-estimate is $1.25 per barrel from 2015 to 2040 (1.3% of the average world oil price over the same time period) in a range of $0.58–$3.46.

3.4.3. Oil security premiums for imported vs. domestic oil

As shown in Fig. 7, the oil security premium for the substitution of imported oil for domestic oil rises only moderately from 2015 to 2040. The gains in the oil security premium for consumption of imported oil are nearly offset by gains in the oil security premium for consumption of domestic oil. As shown in the figure, PVL-O finds the premium rising from a mid-value of $1.44 per barrel (in a range of $0.39–$3.99) in 2015 to a mid-value of $1.64 per barrel (in a range of $0.33–$4.46) in 2040. Under PVL-C, the premium rises from a mid-value of $1.08 per barrel (in a range of $0.12–$3.67) in 2015 to a mid-value of $1.12 per barrel (in a range of $0.09–$3.19) in 2040. Under PVL-O, the premium rises from a mid-value of $1.44 per barrel (in a range of $0.39–$3.99) in 2015 to a mid-value of $1.64 per barrel (in a range of $0.33–$3.19) in 2040. Under PVL-N, the premium rises from a mid-value of $0.38 per barrel (in a range of $0.19–$0.99) in 2015 to a mid-value of $0.39 per barrel (in a range of $0.18–$1.05) in 2040.

For PVL-O, the mid-estimate of the oil security premium for the substitution of imported oil for domestic oil averages $1.56 per barrel from 2015 to 2040 (1.6% of the average world oil price over the same time period) in a range of $0.37–$4.30. For PVL-C, the mid-estimate is $1.13 per barrel from 2015 to 2040 (1.2% of the average world oil price over the same time period) in a range of $0.11–$3.41. For PVL-N, the mid-estimate is $0.39 per barrel from 2015 to 2040 (0.4% of the average world oil price over the same time period) in a range of $0.19–$1.04.

3.4.4. Some implications of the aggregate oil security premiums

In examining the three sets of aggregate oil security premiums, we can draw some preliminary implications. For all three of the models, the oil security premiums are fairly small in comparison to the projected world oil prices. For any given model, the differences between the oil security premiums for the consumption of imported and domestic oil are smaller still.

As demonstrated by the differences in the estimated oil security premiums between PVL-O and PVL-N, the newer economics literature is consistent with much lower estimates of the oil security premiums. The lower estimates found with PVL-N are the result of assuming demand is considerably more elastic in the short run and the U.S. economy is considerably less vulnerable to the oil price shocks than was found in the older literature. These newer estimates suggest considerably more flexibility in world oil markets and in the U.S. economy's ability to cope with the reduced availability of oil. PVL-C takes a compromise approach by combining the older and newer literature.

4. Further thoughts about estimating the oil security premiums

The differing estimates of the oil security premiums leave unresolved how well the parameters from the newer literature represent how world oil markets and the U.S. economy would respond to a sizable oil supply disruption. Recognizing that individuals may prefer newer research to older, four issues need addressing: 1) Does the newer literature adequately capture how world oil markets and the U.S. economy would respond to large oil supply disruptions? 2) Do reduced U.S. oil imports weaken the response of U.S. real GDP to oil supply disruptions? 3) Does a reduced U.S. oil-to-GDP ratio affect the response of U.S. real GDP to oil supply disruptions? 4) To fully assess the risks of U.S. oil consumption, is it necessary to consider U.S. exposure to foreign oil demand shocks?

4.1. The lack of big oil supply disruptions in the modern era

Considering the differences between the current U.S. economy and that of the 1970s, the effects of any oil price shocks are likely smaller than was estimated with data from the era in which the big oil supply shocks occurred. Oil consumption has likely become more flexible. The economy is better able to adjust to oil price shocks; consumers and businesses better know the effects of oil supply disruptions and monetary policy is better informed about how to respond to supply disruptions. Underscoring the effects of changes in the economy, Herrera (2016) uses rolling windows to find the elasticity of U.S. real GDP with respect to oil prices declines from the 1990s to the 2010s.

Some of the older literature found that U.S. GDP responded asymmetrically to world oil price shocks—with increased prices having a much bigger negative effect on economic activity than decreased prices having a positive effect on economic activity. Contributions include Mork (1989), Hamilton (1996, 2003), Davis and Haltiwanger (2001) and Balke et al. (2002). The asymmetric specification allowed U.S. GDP to respond strongly to an oil supply disruption.

Since Kilian and Vigfusson (2011a, 2011b) specified a new set of tests for asymmetry and macroeconomic modelers began using newer data sets, however, no peer-reviewed articles have found an asymmetric relationship between oil prices and U.S. GDP.[9] In the newer literature, which is specified with symmetry and relies on data sets that mostly exclude big disruptions, the elasticity of U.S. real GDP with respect to oil price shocks has been much lower.

Huntington (forthcoming) cautions, however, that the world has not seen a major oil supply disruption since 2003, which raises the concern that newer research, which relies on recent data, may not capture the effects of major oil supply disruptions. Big oil supply disruptions may put more stress on economic relationships than the small oil supply disruptions we have seen in recent years, yielding stronger and asymmetric responses. Underscoring this perspective, Van Robays (2016) finds that global economic uncertainty increases the responsiveness of oil prices to oil supply disruptions. Consequently, large oil supply disruptions might generate more inelastic supply and demand responses and a stronger GDP response than would be suggested by models using recent data. The oil security premiums would be better represented by PVL-O.

Because we have not observed a modern economy with large oil supply disruptions, we have no reliable method to quantify the effects of these disruptions. Nonlinear models would allow the elasticities to vary with the size of disruptions but would not put any additional observations of large oil supply disruptions into a modern economy. Extending the data used for estimation farther back in time increases the possibility of structural change that is not well captured by the model. The result could be an average of old and new results or estimation problems and a poor fit.

If we consider a world in which the economy responds to small oil supply disruptions in a manner that is well captured by the newer literature and to big supply disruptions in a manner that is better captured by the older literature, we can consider an exercise in which the elasticities used to evaluate the security premiums evolve with the size of the disruptions. We could use elasticities from the newer literature for small oil supply disruptions and elasticities more similar to those found in the older literature for the big oil supply disruptions, with graduated intermediate elasticities to cover the transition from small disruptions to big disruptions. The resulting oil security premiums would lie somewhere between the estimates found with PVL-N and those found with PVL-O. If we consider the range of estimates that it provides, PVL-C might best reflect the uncertainty in what we know about the oil security premiums.

[9] Herrera et al. (2015) find that some U.S. industries respond asymmetrically to oil price shocks, but they reject asymmetry in the aggregate.

4.2. Reduced U.S. oil imports

From 2005 to 2015, imports declined from 60% of U.S. oil consumption to 24%. U.S. reliance on oil imports is projected to decline further in the *2016 AEO* (EIA, 2016). Because reduced U.S. oil imports are the result of increased U.S. oil production, we see an increase in the share of stable oil supplies in the world oil market, which cushions the price effects of a given disruption. The present analysis captures this effect.

What reduced reliance on oil imports does not do, however, is prevent a global oil price shock from reaching the United States. Because oil is a fungible commodity, the price shocks resulting from supply disruptions elsewhere in the world are transmitted to the U.S. economy without regard to the quantity of oil that is imported. The present analysis incorporates this mechanism.

As the United States moves toward zero net oil imports, however, the losses in the sectors of the economy that are hurt by oil price shocks will be increasingly offset by the gains in the sectors of the economy that benefit from oil price shocks. Brown and Yücel (1995, 2013) have quantified these effects at the state level. Balke and Brown (2017) show that reducing the share of U.S. oil imports below recent historical averages can substantially weaken the response of U.S. real GDP to oil prices, and Peersman and Van Robays (2012) show that oil import dependence plays an important role in cross-country differences in the response to oil price shocks. Such effects are beyond the present analysis.

4.3. A reduced oil-to-GDP ratio

From 1973 to 2015, the U.S. oil-consumption-to-GDP ratio has declined by more than 60%. Examining eight OECD counties, Brown et al. (1996) found preliminary evidence that oil-importing countries with higher oil-to-GDP ratios faced more difficult trade-offs in inflation and GDP losses in response to oil price shocks than oil importing countries with lower oil-to-GDP ratios. Similarly, Bastianin et al. (2017) find that the effects of oil price shocks increase with energy dependence for Mediterranean countries in the European Union. Although such research suggests that a reduced oil-to-GDP ratio could weaken the response of the U.S. economy to oil price shocks, the author is not aware of any peer-reviewed empirical research that shows such an effect for the United States.

4.4. Foreign oil demand shocks

Oil security premiums rely on estimates of the price effects of world oil supply disruptions, but do not take into account probable foreign demand shocks. Identifying foreign oil demand shocks as an external security cost of oil consumption does not seem appropriate. Unless there is a Fukushima-like event that shifts Japanese electric power generation from nuclear power plants to those that are oil-fired, unexpected growth in global oil demand is not likely to yield sudden oil price movements because oil demand changes slowly. There also seems to be no reason to be more concerned about the effects of international business cycles affecting the U.S. economy through variations in oil demand than any other channel through which business cycles are transmitted.

5. Evaluating policy with the oil security premiums

Ultimately, the purpose of estimating the security costs of U.S. dependence on oil consumption is to provide guidance for energy policy. The differing assumptions made about the elasticities can lead to substantially different estimates of the costs of U.S. dependence on oil. The range of estimates are consistent with relatively little intervention in U.S. oil markets or considerably more intervention, although the newer estimates mostly suggest relatively little intervention. A comparison

Table 9
Aggregate oil security premiums, 2015–40 average (2015 U.S. Dollars per barrel).
Source: Model estimates.

Model	Consumption of imported oil	Consumption of domestic oil	Imported vs. domestic oil
PVL-O	$6.92 $1.47–$20.03	$5.36 $1.10–$15.73	$1.56 $0.37–$4.30
PVL-N	$1.64 $0.77–$4.50	$1.25 $0.58–$3.46	$0.39 $0.19–$1.04
PVL-C	$4.83 $0.40–$15.62	$3.70 $0.29–$12.21	$1.13 $0.11–$3.41

with estimated environmental costs may be informative.

Parry et al. (2014) provides a recent and fairly complete assessment of the environmental costs of U.S. oil use. In 2015 dollars, Parry et al. place the estimated social costs that result from U.S. oil consumption at $12.11 per barrel for non-CO_2 emissions and $16.46 per barrel for CO_2 emissions.[10]

As shown in Table 9, the upper ranges of the oil security estimates from both PVL-O and PVL-C put the costs of U.S. reliance on imported oil or domestic oil close to the environmental costs of U.S. oil use. In contrast, the mid- and lower ranges of PVL-O and PVL-C and all the estimates from PVL-N provide security cost estimates for U.S. consumption of imported oil that are important but considerably lower than the environmental costs. Although the security costs of domestic oil consumption are lower, the mid-estimates from PVL-O and PVL-C find that U.S. consumption of domestic oil yields important security costs. Reliance on imported oil over domestic oil has a small security cost.

Taken together, the estimated costs of U.S. oil dependence and the environmental costs of U.S. oil consumption suggest the possibility of some tension in the development of U.S. policy toward oil consumption, oil imports and domestic oil production. At one extreme, some policymakers and analysts will see U.S. oil security as nearly an equally important issue to the environmental costs of oil use. At another extreme, some policymakers and analysts will think that U.S. oil policy ought to focus more on the environmental costs of oil use rather than the fairly low security costs.[11]

Although the policymakers and analysts may not focus on the elasticity assumptions that underlie the different estimates of the oil security premiums, the estimates depend greatly on these assumptions. Flexibility in world oil consumption, world oil production and in the U.S. economy's ability to cope with reduced oil supplies is critical to the low estimates of the oil security premiums. If the world oil market and the U.S. economy are not as flexible as the newer elasticities indicate, the price shocks and economic losses will be greater. Larger oil supply disruptions, which are mostly outside the estimation range of the newer models, may put more stress on economic relationships than the small oil supply disruptions we have seen in recent years, yielding stronger responses.

6. Concluding remarks

A fair amount of previous work addresses the non-environmental costs of U.S. oil consumption with much of it taking the approach that these costs exceed the market price paid for the oil. The current work has taken the oil security approach (developed by Brown and Huntington, 2013) to estimate the non-environmental costs of U.S. consumption of imported oil, U.S. consumption of domestic oil and the substitution of imported oil for domestic oil from 2015 to 2040.

The oil security premiums for U.S consumption of imported and domestic oil includes only two components: the change in the expected GDP loss and the change in the expected transfers for the inframarginal barrels of imported oil that result from an oil supply disruption. Under this approach, the monopsony premium and the expected transfers on the marginal barrel of imported oil are excluded because the first is measured under stable market conditions and the latter is a cost that should be anticipated. The oil security premium for the substitution of imported oil for domestic oil is the difference between the premiums for the consumption of imported oil and the consumption of domestic oil.

A computational model based on a welfare-theoretic approach is used to evaluate three different sets of parameter values with the reference case projections for world oil market conditions in the *2016 AEO* (EIA, 2016). Three sets of parameter values are taken from surveys of the economics literature. PVL-O represents the older literature in which oil demand is less elastic and GDP is more sensitive to oil price shocks; PVL-N represents the newer literature in which oil demand is more elastic and GDP is less sensitive to oil price shocks; and PVL-C combines the old and new literature to better reflect the uncertainty about the response of world oil markets and the U.S. economy to world oil supply disruptions.

Changes in world oil market conditions from those expected a few years ago—such as increased U.S. oil production—mean smaller expected oil price shocks, weaker expected effects of U.S. GDP and smaller expected transfers on inframarginal oil imports, which contribute to somewhat smaller estimates of oil security premiums. The newer literature also suggests world oil demand is more elastic and that U.S. real GDP is less responsive to oil price shocks than was previously thought, and these new elasticities contribute to considerably smaller estimates of the oil security premiums.

We are left with a concern that the newer estimates better capture the market response and macroeconomic effects of the smaller oil supply disruptions that have occurred in recent years than the big oil supply disruptions that occurred in the 1970s and 1980s. The world oil market may have become more flexible and the U.S. economy's flexibility in responding to oil price shocks likely has increased as people better understand and are better able to cope with oil supply disruptions and as monetary policy is better informed about how to respond to supply disruptions. But, big oil supply disruptions are likely to put more stress on economic relationships than the small oil supply disruptions seen in recent years.

Nonetheless, only the highest estimates of the oil security premiums suggest that U.S. oil security is nearly an equally important issue to the environmental costs of oil use. The mid-estimates from the model that may best represent how the world oil market and the U.S. economy will respond to world oil supply disruptions of various sizes (PVL-C) find U.S. consumption of imported or domestic oil does yield important security costs, but those costs are much lower than the estimated environmental costs of oil use. Consistent with Brown and Huntington (2013), the substitution of domestic oil for imported oil only slightly improves U.S. oil security. Oil conservation is more effective than increased domestic oil production at improving U.S. oil security.

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[10] The somewhat older estimates of the National Research Council (2009) are similar at $16.79 for non-$CO_2$ emissions and $15.68 per barrel for CO_2 emissions, the latter in a range of $0.52–$44.42 per barrel.

[11] For some policy instruments, such as taxes, the pursuit of environmental and oil security goals can be complementary activities. In other cases, policymakers may face tradeoffs in the pursuit of environmental and oil security goals. See Brown and Huntington (2008).

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Appendix A. The welfare-analytic approach

To assess the costs of U.S. oil consumption, we develop a simple welfare-analytic model of U.S. oil consumption similar to that of Brown and Huntington (2013, 2015). We use the model to examine which of the different costs that are associated with U.S. oil consumption ought to be considered market failures. We use the model as a basis for estimating the security costs of U.S. consumption of imported and domestic produced oil as shown in Appendix B.

The economic welfare the United States obtains from its oil consumption, imports and production is the sum of U.S. consumer and producer surpluses associated with oil less the environmental costs of oil use and the expected losses associated with the insecurity of imported or domestic oil, as follows:

$$W = \int_0^{Q_C} P_D(Q)\partial Q - TC_{US} - P_W Q_M - E(\Delta P_W)\bullet Q_M - E(\Delta Y) - X_C Q_C \tag{A.1}$$

where W is the expected welfare associated with U.S. oil consumption, production and imports; Q_C is the quantity of oil consumed in the United States; P_D is the value U.S. consumers place on the marginal barrel of oil consumed at each quantity Q, which takes the value P_{US} at Q_C; TC_{US} is the total cost of U.S. oil production, P_W is the world oil price; Q_M is the quantity of U.S. oil imports; $E(\Delta P_W)\cdot Q_M$ is the expected transfers from the United States to the rest of the world as a result of the higher oil prices that result from world oil supply disruptions; $E(\Delta Y)$ is the expected value of the U.S. GDP losses occurring as the result of world oil supply disruptions; and X_C is the value of the environmental externalities associated with U.S. oil consumption.[12] As in Brown and Huntington (2013), Eq. (A.1) treats oil as a fungible commodity that trades at a globally determined price.

A.1. The optimal consumption of imported oil

For the consumption of imported oil, the optimality condition is:

$$P_{US} = P_W + \frac{\partial P_W}{\partial Q_M}Q_M + E(\Delta P_W) + \frac{\partial E(\Delta P_W)}{\partial Q_M}Q_M + \frac{\partial E(\Delta Y)}{\partial Q_M} + X_C \tag{A.2}$$

The optimal consumption of imported oil occurs when the value U.S. consumers place on the last barrel of imported oil they consume is equal to the world oil price plus changes in the U.S. terms of trade for oil that result from importing an additional barrel of oil, the change in the expected transfers from the United States to the rest of the world as a result of the higher oil prices that result from world oil supply disruptions that can be attributed to consuming an additional barrel of imported oil, the change in the expected GDP loss that results from a world oil supply shock that can be attributed to consuming an additional barrel of imported oil, and the environmental externalities associated with additional oil consumption.[13] Other than environmental externalities, the components of Eq. (A.2) are the basis for assessing security premiums for U.S. consumption of imported oil.

A.2. The optimal consumption of domestic oil

For the consumption of domestic oil, the optimality condition is:

$$P_{US} = MC_{US} + \frac{\partial E(\Delta P_W)}{\partial Q_D}Q_M + \frac{\partial E(\Delta Y)}{\partial Q_D} + X_C \tag{A.3}$$

The optimal consumption of domestic oil occurs when the value that U.S. consumers place on the last barrel of domestic oil is equal to the marginal cost of producing that barrel of oil (MC_{US}), the change in the expected transfers from the United States to the rest of the world as a result of the higher world oil prices that result from world oil supply disruptions that can be attributed to consuming an additional barrel of domestic oil, the change in the expected GDP loss that results from a world oil supply shock that can be attributed to consuming an additional barrel of domestic oil, and the environmental externalities associated with additional oil consumption. Other than environmental externalities, the components of Eq. (A.3) are the basis for assessing security premiums for U.S. consumption of domestic oil.

A.3. The external security costs of U.S. oil consumption

With a well-functioning market, oil consumers are expected to fully consider the private costs of their actions. In contrast, oil consumers are expected to ignore the costs that their consumption of oil may impose on others. Accordingly, deviations from the optimal U.S. consumption of imported and domestic oil occur only to the extent that the costs identified in Eqs. (A.2) and (A.3) are regarded as externalities. In addition, some of the external costs of oil use are not security costs because they do not arise from world oil market instability. Sections A.3.1–A.3.4 evaluate whether the costs identified ought to be regarded as external security costs and used in the evaluation of the security costs of U.S. oil consumption.

A.3.1. Changes in the terms of trade for imported oil (monopsony premium)

Most previous analyses of the costs of U.S. reliance on oil imports, starting with Landsberg et al. and continuing through Leiby (2008) and Greene (2011), have included as a cost of U.S. dependence on imported oil the cost that additional oil imports would impose on the inframarginal consumers of oil during stable-market conditions, $\frac{\partial P_W}{\partial Q_M}Q_M$. Decreasing U.S. oil imports would lower the price all U.S. consumers pay for all imported oil, but

[12] The term *oil* is taken to include crude oil, refined products, and all liquid fuels that are close substitutes for refined products. The analysis is also simplified by the assumption that the environmental externalities associated with the consumption of either imported or domestic oil are the same.

[13] The analysis implies that the United States should set the domestic price of oil (P_{US}) above the world oil price (P_W).

individual U.S. consumers have no incentive to differentiate between domestic and imported oil when making their purchases. Consequently, the consumption of the marginal barrel of imported oil imposes a cost on U.S. consumers that depends on the size of U.S. oil imports. Although the incremental price change resulting from the marginal barrel of imports is relatively small, when summed across total U.S. oil imports, the cost is fairly sizable.

Because the monopsony premium arises during stable oil market conditions rather than being the result of expected oil supply disruptions, Brown and Huntington (2013) exclude it from their measure of the oil security premium. They further note that these transfers are what economists identify as a pecuniary externality, rather than a true externality. The transfers are a cost to the United States but a net wash to the world because the transfers paid by U.S. consumers are received by foreign oil producers.

A.3.2. A change in the transfers resulting from oil supply disruptions

As is documented by the U.S. Energy Information Administration (EIA) (2017) and Huntington (forthcoming), international oil supply disruptions have led to sharp oil price increases and U.S. economic losses. These losses include transfers from U.S. consumers to foreign oil producers. To the extent that international oil supply disruptions result in economic losses that are not taken into account by consumers in making their decisions about use, they are externalities that impose costs on others.

As shown in Eq. (2) and explained by Brown and Huntington (2013), these transfers consist of two elements for imported oil. The purchaser of the marginal barrel faces an expected oil price shock, $E(\Delta P_W)$. In addition, the purchase of additional imported oil boosts non-U.S. oil production and increases the size of expected oil supply disruption. The result is a bigger expected oil price shock for consumers of the inframarginal barrels of imported oil, with an increase of expected loss, $\frac{\partial E(\Delta P_W)}{\partial Q_M} Q_M$.

Brown and Huntington argue that the former element is not an externality because the purchaser of oil (or oil-using goods) ought to be able to understand that oil consumption is subject to oil price shocks.[14] On the other hand, the latter element should be considered an externality to the United States because U.S. consumers are not likely to take into account how their own oil purchases may affect the price shocks seen by other U.S. consumers. When summed across total U.S. oil imports, the latter effect can be fairly sizable. Nonetheless, the change in these expected transfers are a pecuniary externality, rather than a true externality. The transfers are a cost to the United States but a net wash to the world because the increased transfers paid by U.S. consumers during an oil supply disruption are received by foreign oil producers.

As shown in Eq. (3), the transfers consist of one element for U.S. consumption of domestic oil, the change in the expected oil price shock for the inframarginal barrels of imported oil, $\frac{\partial E(\Delta P_W)}{\partial Q_D} Q_M$. As explained by Brown and Huntington (2013), increasing U.S. domestic oil production increases the share of world oil production coming from stable sources.[15] Hence, increased domestic production dampens the expected price shock from oil supply disruptions, which decreases the expected transfers for the inframarginal barrels of imported oil. Because the benefits of smaller price shocks are conferred across all U.S. oil consumers, an individual making a decision to buy oil (or oil-using goods) will not take these benefits into account, and an externality arises.

A.3.3. Changes in the GDP losses resulting from oil supply disruptions

Oil price shocks have preceded 10 of the 11 U.S. recessions since World War II. Although the economics literature is divided on the exact size of the effect that oil price shocks have on aggregate economic activity, these recessions underscore the idea that oil supply disruptions are likely to result in losses in U.S. real GDP. In addition to the direct effects associated with reduced oil resources to use in production and consumption, economic research has variously attributed the losses to market power and search costs (John, 1995), imperfect competition (Rotemberg and Woodford, 1996), failures in monetary policy (Bohi, 1989, 1991; Bernanke et al., 1997; Barsky and Kilian, 2002, 2004), the costs of reallocating resources (Mork, 1989; Davis and Haltiwanger, 2001), the effects of uncertainty on investment (Hamilton, 1996, 2003; Ferderer, 1996; Balke et al., 2002), and coordination failures (Huntington, 2003).

For whatever reason that oil supply disruptions have effects on U.S. economic activity, the losses extend throughout the economy and are much greater than an individual might expect as part of an oil purchase. Consequently, consumers are unlikely to understand or consider how their own oil consumption affects the loss of economic activity resulting from world oil supply disruptions, which renders the expected losses in U.S. real GDP as externalities.

Increased U.S. oil consumption increases the economy's exposure to the losses in real GDP associated with oil supply disruptions, but the effects are different for imported and domestic oil. As described in Section 3.3.2 above, increased U.S. oil imports boost production of the unstable sources of world oil supply, which would strengthen the oil price shocks resulting from oil supply disruptions, and exacerbate the expected GDP loss, $\frac{\partial E(\Delta Y)}{\partial Q_M}$. In contrast, increased domestic oil production boosts the secure elements of world oil supply, dampens the oil price shocks from oil supply disruptions and lessens the GDP loss, $\frac{\partial E(\Delta Y)}{\partial Q_D}$. It follows that the expected GDP loss from an increase in the consumption of imported oil is greater than for an increase in the consumption of domestic oil.

A.3.4. Environmental externalities

As has been examined in the economics literature, the consumption of either domestic or imported oil yields environmental costs that are externalities. Because the environmental externalities of oil use are not a security issue, an examination of these externalities is beyond the scope of the present inquiry.

A.3.5. Foreign policy costs of U.S. oil imports

The Council on Foreign Relations (2006) identifies six foreign policy costs that arise from U.S. consumption of imported oil. These costs include 1) The adverse effect that significant disruptions in oil supply will have for political and economic conditions in the United States and other importing countries; 2) The fears that the current international system is unable to ensure secure oil supplies when oil is seemingly scarce and oil prices are high; 3) Political realignment from dependence on imported oil that limits U.S. alliances and partnerships; 4) The flexibility that oil revenues give oil-exporting countries to adopt policies that are contrary to U.S. interests and values; 5) An undermining of sound governance by the

[14] In practice, consumers may not fully understand the probabilities of future oil supply disruptions and the accompanying price shocks, which could result in losses that are not fully considered in the decision process.

[15] Increased production in stable foreign countries, such as Canada, also increases the security of world oil supply.

revenues from oil and gas exports in oil-exporting countries; and 6) An increased U.S. military presence in the Middle East that results from the strategic interest associated with oil consumption. Brown and Huntington (2015) find these six costs are either implicitly incorporated in the welfare-theoretic analysis, are not externalities or cannot be quantified. To the extent these costs are externalities that cannot be quantified, the measured security costs of U.S. reliance on imported oil will be understated.

A.3.6. The cost of government policies to enhance U.S. oil security

As they have been conceived, the security estimates exclude the costs of government policies for mitigating the disruption costs. Such costs might include the foreign policy costs, defense spending or the strategic petroleum reserve. As Bohi and Toman (1993) and Brown and Huntington (2013) explain, such expenditures should not be considered a measure of the externality. Rather, the expenditures are a response to the externality.

Appendix B. Computing the components of the oil security premiums

Most broadly conceived, the oil premiums comprise six elements: 1) the monopsony premium, 2) the expected transfer on the marginal barrel of imported oil (which is equal to the expected price shock), 3) the change in the expected U.S. GDP loss as the result of a marginal increase in U.S. consumption of imported oil, 4) the change in the expected U.S. GDP loss as the result of a marginal increase in U.S. consumption of domestic oil, 5) the change in expected transfers on the inframarginal barrels of imported oil as a result of a marginal increase in U.S. consumption of imported oil, and 6) the change in expected transfers on the inframarginal barrels of imported oil as a result of a marginal increase in U.S. consumption of domestic oil. Brown and Huntington (2015) provide guidance in the calculation of all six components.

B.1. The monopsony premium

As described in Section A.3.1 above, the monopsony premium for any given year is

$$MP = \frac{\partial P_W}{\partial Q_M} Q_M \tag{B.1}$$

where MP is the monopsony premium, P_W is the world price of oil and Q_M is the quantity of U.S. oil imports.

Eq. (B.1) can be evaluated with market quantities and price and the long-term elasticities of non-U.S. supply and demand as follows:

$$MP = \frac{P_W}{\eta_{SLR}\left(\frac{QS_{ROW}}{Q_M}\right) - \eta_{DLR}\left(\frac{QD_{ROW}}{Q_M}\right)} \tag{B.2}$$

where η_{SLR} is the long-run price elasticity of world oil supply, QS_{ROW} is the quantity of oil produced outside the United States, η_{DLR} is the long-run price elasticity of world oil demand and QD_{ROW} is the quantity of oil consumed outside the United States.

B.2. Expected transfers on the marginal barrel of imported oil

As described in Section A.3.2 above, the consumer of the marginal barrel of oil faces an expected oil price shock, $E(\Delta P_W)$, which is transferred to the oil producers. For the consumer of the marginal barrel of domestic oil, the transfer is a net wash for the United States. For the consumer of the marginal barrel of imported oil, the transfer goes to foreign producers. As described above, this transfer should not be considered an externality.

Evaluating the expected price increase for any given year involves summing over the products of the probabilities of individual disruptions and the oil price shocks that would result from those disruptions, as follows:

$$E(\Delta P_W) = \sum_{i=0}^{n} \varphi_i \bullet \Delta P_{Wi}(D_i) \tag{B.3}$$

where $E(\Delta P_W)$ is the expected price increase over $n + 1$ different sized oil-supply disruptions including zero disruption, φ_i is the probability of disruption D_i, $\Delta P_{Wi}(D_i)$ is the increase in price resulting from disruption D_i, and $\sum_{i=0}^{n} \varphi_i = 1$.

For each given oil supply disruption in a given year, the resulting price is

$$\Delta P_{Wi} = P_W((Q_W - D_i)/Q_W)^{1/\eta} - P_W \tag{B.4}$$

where ΔP_{Wi} is the change in price from disruption D_i, P_W is the world oil price before the supply disruption, Q_W is world oil consumption before the disruption and η is an encompassing short-run elasticity that takes into account world oil market conditions and a number of elasticities as follows:

$$\begin{aligned}\eta \ \equiv\ & (\eta_{DUS} + \eta_{YUS}\eta_{GUS})\frac{QD_{US}}{Q_W} + (\eta_{DROW} + \eta_{YROW}\eta_{GROW})\frac{QD_{ROW}}{Q_W} \\ & - \ \eta_{SUS}\frac{QS_{US}}{Q_W} - \eta_{SROW}\frac{QS_{ROW}}{Q_W}\end{aligned} \tag{B.5}$$

where η_{DUS} is the short-run price elasticity of U.S. oil demand, η_{YUS} is the U.S. income elasticity of oil demand, η_{GUS} is the elasticity of U.S. real GDP with respect to oil prices, QD_{US} is the quantity of U.S. oil consumption, η_{DROW} is the short-run price elasticity of ROW oil demand, η_{YROW} is the ROW income elasticity of oil demand, η_{GROW} is the elasticity of ROW real GDP with respect to oil prices, QD_{ROW} is the quantity of ROW oil consumption, η_{SUS} is the short-run price elasticity of U.S. oil supply, QS_{US} is U.S. oil production, η_{SROW} is the short-run price elasticity of ROW oil supply, and QS_{ROW} is ROW oil production.

B.3. Change in expected transfers on inframarginal oil imports

To evaluate the change in expected transfers on the inframarginal barrels of imported oil, the quantity of U.S. oil imports is computed for each size disruption, D_i. World oil market conditions also are adjusted to a new equilibrium for a small increase in U.S. oil consumption of either imported or domestic oil. A new set of disruption prices are calculated. The change in transfers on inframarginal imports is calculated for each size disruption and aggregated as follows:

$$\Delta E(\Delta P_W)\bullet Q_M = \sum_{i=0}^{n} \varphi_i \bullet Q_{Mi}(D_i)\bullet(\Delta P'_{Wi}(D_i) - \Delta P_{Wi}(D_i)) \tag{B.6}$$

where $\Delta E(\Delta P_W)\bullet Q_M$ is the change in expected transfers on inframarginal oil imports, $Q_{Mi}(D_i)$ is the quantity of U.S. imports during disruption D_i, and $\Delta P'_i(D_i)$ is the increase in price resulting from disruption D_i with increased U.S. consumption of imported or domestic oil.[16]

B.4. Change in the expected U.S. real GDP losses

For a given oil supply disruption in a given year the resulting loss in U.S. real GDP is

$$\Delta Y_i = Y_{US}\bullet\left(\frac{P_W + \Delta P_{Wi}(D_i)}{P_W}\right)^{\eta_{GUS}} - Y_{US} \tag{B.7}$$

where ΔY_i is real GDP loss from supply disruption D_i and Y_{US} is U.S. real GDP before the supply disruption.

The expected U.S. real GDP loss is the sum of the products of the probabilities of individual disruptions and the U.S. real GDP losses that would result from those disruptions, as follows:

$$E(\Delta Y) = \sum_{i=0}^{n} \varphi_i \bullet \Delta Y_i(D_i) \tag{B.8}$$

To evaluate the change in expected real GDP losses for an increase in either imported or domestic oil, world oil market conditions are adjusted to a new equilibrium for a small increase in U.S. oil consumption of either imported or domestic oil. A new set of disruption prices and expected real GDP losses are computed.[17] The difference between the two estimates is the change in the expected U.S. GDP loss.

$$\Delta E(\Delta Y) = \sum_{i=0}^{n} \varphi_i \bullet \Delta Y'_i(D_i) - (\Delta Y_i(D_i) \tag{B.9}$$

where $\Delta E(\Delta Y)$ is the change in the expected U.S. real GDP loss and $\Delta Y'_i(D_i)$ is the U.S. real GDP loss from disruption D_i with increased U.S. consumption of either imported or domestic oil.

Appendix C. Traditional oil premiums

The traditional premium for U.S consumption of imported oil includes four components; the monopsony premium, the expected transfers on the marginal barrel of imported oil, the change in the expected transfers for the inframarginal barrels of imported oil, and the change in the GDP loss resulting from an oil price shock. The traditional premium for U.S consumption of domestic oil includes two components: the change in the expected transfers for the inframarginal barrels of imported oil and the change in the GDP loss resulting from an oil price shock. The traditional premium for the substitution of imported oil for domestic oil is the difference between the premiums for the consumption of imported and domestic oil.

Section 3 above quantifies the expected GDP losses and the expected transfers for the inframarginal barrels of imported and domestic oil. This appendix uses the computational methods explained in Appendix B with 2014 world oil market conditions and those projected by the U.S. Energy Information Administration (EIA) (2012, 2016) to quantify the monopsony premium and the expected transfers on the marginal barrel of imported oil. It also combines these two components with the expected GDP losses and transfers on inframarginal imports to quantify traditional oil premiums. In addition, it examines briefly the implications of using the traditional premiums in thinking about U.S. energy policy.

C.1. Traditional oil premiums, from Brown-Huntington to the newer measures

Using the methods, oil market conditions, the probability and sizes of disruptions and the elasticities described in Section 3.1 above, we develop four sets of traditional oil premiums. These include a replication of Brown-Huntington (2015), PVL-O which uses updated world oil market conditions and probabilities and sizes of disruptions, PVL-N which uses the newer estimates of the short-run elasticity of demand and the response of GDP to oil price shocks, and PVL-C which combines the older and newer estimates of the short-run elasticity of demand and the response of U.S. real GDP to oil price shocks.

C.1.1. Additional components of the traditional oil premiums

As shown in Table C.1, the monopsony premium is greater for the Brown-Huntington assumptions than for PVL-O, PVL-N or PVL-C. The reduced values found with the PVL cases owe to substantially lower U.S. oil imports that occurred in 2014 than EIA (2012) projected for the 2013–14 average. The non-U.S. long-run demand and supply elasticities are taken from Brown-Huntington (2015) and are the same for all four sets of calculations. The mid-value of the long-run demand elasticity is − 0.40 in a range of − 0.35 to − 0.45, and the mid-value of the long-run supply elasticity is 0.40 in a range of 0.35 − 0.45.

As also is shown in the table, the expected transfer on the marginal barrel of imported oil is greater for the Brown-Huntington assumptions than any of the PVL cases. With the same elasticities, the differences between the two estimates primarily owes to U.S. oil production accounting for a greater share of world oil production under PVL-O. As a result of greater demand elasticities, PVL-N shows smaller expected price shocks than PVL-O.

PVL-C shows a wider range with higher mid- and upper estimates of the expected price shocks than PVL-O and a low that is nearly the same as the low for PVL-N. The higher estimates for the mid- and upper range values depend on GDP being less responsive, which makes effective demand more

[16] As explained in Section A.3.2 above, the purchase of additional imported oil boosts non-U.S. oil production and increases the size of expected oil supply disruptions, which increases the expected oil price shock for consumers of the inframarginal barrels of imported oil. In contrast, the purchase of additional domestic oil dampens the expected price shock from oil supply disruptions, which decreases the expected transfers for the inframarginal barrels of imported oil.

[17] As explained in Section A.3.3 above, a greater value is obtained for an increase in the consumption of imported oil than for the consumption of domestic oil. This difference arises because the increase in domestic oil increases the share of world oil from stable producers while the increase in the consumption of imported oil increases the share of world oil from unstable producers.

Table C.1
Additional components of the oil premiums, 2014 (2015 U.S. Dollars per barrel).
Source: Model estimates.

Model	Monopsony premium	Expected oil price shock (transfer on the marginal barrel of imported oil)
Brown and Huntington (2015)	\$17.38 \$15.45–\$19.86	\$7.56 \$5.40–\$16.05
PVL-O	\$8.45 \$7.51–\$9.66	\$6.55 \$4.60–\$14.65
PVL-N	\$8.45 \$7.51–\$9.66	\$3.15 \$2.12–\$6.37
PVL-C	\$8.45 \$7.51–\$9.66	\$7.39 \$2.16–\$17.48

Table C.2
Traditional oil security premiums, 2014 (2015 U.S. Dollars per barrel).
Source: Model estimates.

Model	Consumption of imported oil	Consumption of domestic oil	Imported vs. domestic oil
Brown and Huntington (2015)	\$30.36 \$22.04–\$51.61	\$3.17 \$0.26–\$9.60	\$27.19 \$21.78–\$42.01
PVL-O	\$20.28 \$13.26–\$39.53	\$3.60 \$0.60–\$10.63	\$16.68 \$12.66–\$28.90
PVL-N	\$12.90 \$10.23–\$19.48	\$0.78 \$0.34–\$2.24	\$12.12 \$9.89–\$17.24
PVL-C	\$19.55 \$9.99–\$40.58	\$2.34 \$0.12–\$9.00	\$17.21 \$9.87–\$31.58

Table C.3
Additional components of the oil premiums, 2015–40 average (2015 U.S. Dollars per barrel).
Source: Model estimates.

Model	Monopsony premium	Expected oil price shock (transfer on the marginal barrel of imported oil)
PVL-O	\$3.54 \$3.15–\$4.05	\$6.20 \$4.36–13.90
PVL-N	\$3.54 \$3.15–\$4.05	\$3.02 \$2.01–\$6.04
PVL-C	\$3.54 \$3.15–\$4.05	\$7.00 \$2.05–\$16.57

inelastic and yields greater oil price shocks for the expected oil supply disruptions. The low estimate for PVL-C reflects the greater elasticity of short-run demand.

C.1.2. The traditional premiums

As shown in Table C.2, the traditional oil premium for the consumption of imported oil is greater under the Brown-Huntington assumptions than any of PVL cases. The monopsony premium, the expected transfers on the marginal barrel of imported oil, the expected GDP losses and the expected transfers on the inframarginal barrels of imported oil all contribute to the differences. The table also shows that the values of the traditional premium for U.S. consumption of imported oil are mostly greater for PVL-O, with a slightly higher upper value for PVL-C. PVL-N shows lower values than the other two PVL cases.

As shown in the table, estimates of the traditional oil premium for U.S. consumption of domestic oil are greater for Brown-Huntington than PVL-O which is greater than PVL-C and PVL-N. The estimates of the traditional premium for the substitution of imported oil for domestic oil are greater for Brown-Huntington than any of the PVL cases. PVL-C shows systematically higher values than PVL-O. The higher values for PVL-C are the result of a greater difference between its traditional premium for imported and domestic oil, with that difference owing mostly to the expected transfers on the marginal barrel of imported oil.

As shown in the table, PVL-C shows a wider range with higher mid- and upper estimates of the expected price shocks than PVL-O and a low that is nearly the same as the low for PVL-N. The low values found with PVL-N and the low values at the bottom of the PVL-C range owe to more elastic short-run demand. The expected transfers on the marginal barrel of imported oil found for the three modeling efforts are in the lower range of the values found for PVL-N. The lower estimates for these models depend mostly on the more elastic values of short-run supply and demand found with the three models (Table C.3).

As shown in Table C.4, the average findings for the three PVL cases over the 2015–2040 time period are somewhat lower than those found for

Table C.4
Traditional oil security premiums, 2015–40 average (2015 U.S. Dollars per barrel).
Source: Model estimates.

Model	Consumption of imported oil	Consumption of domestic oil	Imported vs. domestic oil
PVL-O	$16.66 $8.98–$37.98	$5.36 $1.10–$15.73	$11.30 $7.88–$22.25
PVL-N	$8.20 $5.93–$14.60	$1.25 $0.58–$3.46	$6.95 $5.35–$11.14
PVL-C	$15.37 $5.60–$38.22	$3.70 $0.29–$13.79	$11.67 $5.31–$24.43

2014 world oil market conditions. The values of the traditional premium for U.S. consumption of imported oil are mostly greater for PVL-O, with a slightly higher upper value for PVL-C. PVL-N shows lower values than the other two PVL cases. Estimates of the traditional oil premium for U.S. consumption of domestic oil are greater for PVL-O than PVL-C which are greater than for PVL-N. For the substitution of imported oil for domestic oil, however, PVL-C shows higher mid- and upper values than PVL-O, while PVL-N shows the lowest values.

C.2. Additional components of the traditional oil premiums 2015–2040

As described above, six components are used to compute the traditional oil premiums. Four of the components—the change in the expected GDP losses from a marginal increase that result from a marginal increase in the consumption of imported oil or domestic oil and the change in expected transfers on inframarginal consumption of imported oil that result from a marginal increase in the consumption of imported or domestic oil—are described in Section 3.3 above. The two additional components are the monopsony premium and the expected transfers on the marginal barrel of imported oil.

C.2.1. The monopsony premium

As shown in Fig. C.1, the monopsony premium generally decreases from 2015 to 2040. Forecasts of declining U.S. oil imports more than offset the effects of the forecasted increase in oil prices. As shown in the figure, the three PVL cases find the monopsony premium falling from a mid-value of $3.81 per barrel (in a range of $3.39–$4.35) in 2015 to a mid-value of $2.52 per barrel (in a range of $2.24–$2.88) in 2040.

C.2.2. Expected transfers on the marginal barrel of imported oil

As shown in Fig. C.2, the expected price shock generally increases from 2015 to 2040. The gains are largely the result of forecasted gains in world oil prices. As shown in the figure, PVL-O finds the premium rising from a mid-value of $3.37 per barrel (in a range of $2.37–$7.52) in 2015 to a mid-value of $8.89 per barrel (in a range of $6.24–$20.04) in 2040. Under PVL-C, the premium rises from a mid-value of $3.81 per barrel (in a range of $1.12–$10.30) in 2015 to a mid-value of $10.04 per barrel (in a range of $2.94–$27.46) in 2040. Under PVL-N, the premium rises from a mid-value of $1.65 per barrel (in a range of $1.09–$3.29) in 2015 to a mid-value of $4.33 per barrel (in a range of $2.88–$8.69) in 2040.

C.3. Traditional oil premiums 2015–2040

Estimates of the individual components are used to develop traditional oil premiums from 2015 to 2040. These premiums cover the consumption

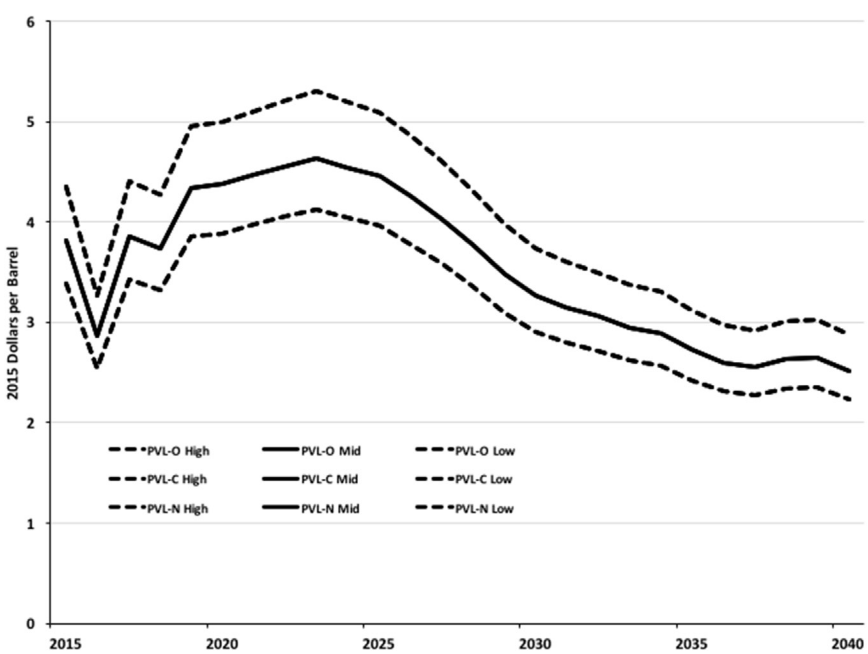

Fig. C.1. Monopsony premiums.

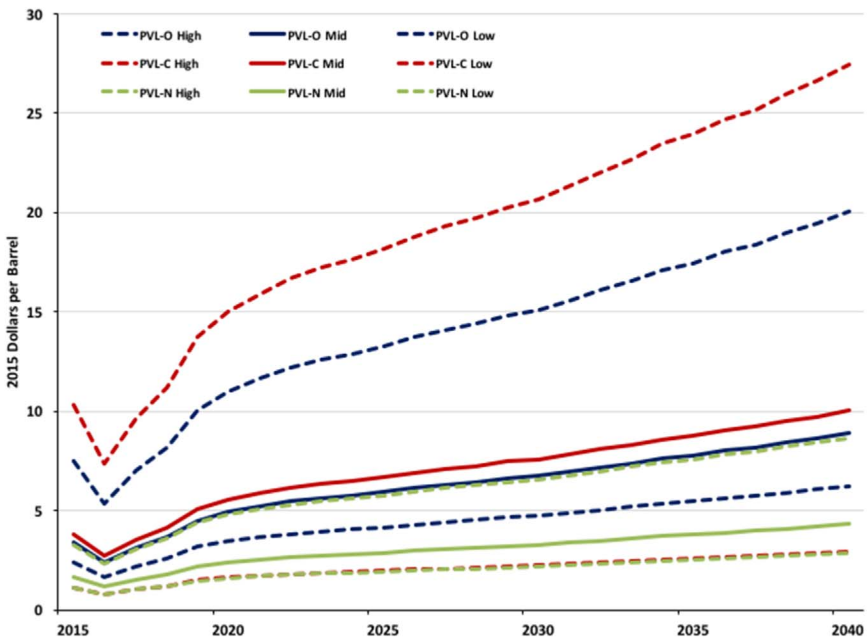

Fig. C.2. Expected oil price shock (expected transfer on marginal barrel of imported oil).

of imported oil, the consumption of domestic oil and the substitution of imported oil for domestic oil. Most of the premiums rise from 2015 to 2040, with projected gains in U.S. real GDP, the world oil price and non-U.S. production more than offsetting the effects of decreased U.S. oil imports. Some of the premiums fall, with the effects of decreased oil imports more than offsetting projected gains in U.S. real GDP, the world oil price and non-U.S. production.

C.3.1. Traditional premiums for the consumption of imported oil 2015–2040

As shown in Fig. C3, the traditional oil premium for U.S. consumption of imported oil increases from 2015 to 2040 for the PVL cases. As shown in the figure, PVL-O shows the premium rising from a mid-value of $12.44 per barrel (in a range of $6.88–$27.03) in 2015 to a mid-value of $20.14 per barrel (in a range of $10.33–$48.22) in 2040. Under PVL-C, the premium rises from a mid-value of $11.29 per barrel (in a range of $4.81–$26.52) in 2015 to a mid-value of $18.64 per barrel (in a range of $5.67–$50.01) in 2040. Although the high range for PVL-C starts below the high range for PVL-O, the former overtakes the latter by 2020 because bigger oil price shocks result from a less responsive GDP in PVL-C, and those effects gradually dominate some of the other processes at work. Under PVL-N, the premium rises from a mid-value of $6.70 (in a range of $5.07–$11.06).

C.3.2. Traditional premiums for the consumption of domestic oil 2015–2040

As shown in Fig. C.4, the traditional oil premium for U.S. consumption of domestic oil increases from 2015 to 2040. The gains are largely driven by expected GDP losses. The expected transfers on inframarginal consumption of imported oil are quite small. As shown in the figure, PVL-O finds the premium rising from a mid-value of $3.81 per barrel (in a range of $0.74–$11.17) in 2015 to a mid-value of $7.09 per barrel (in a range of

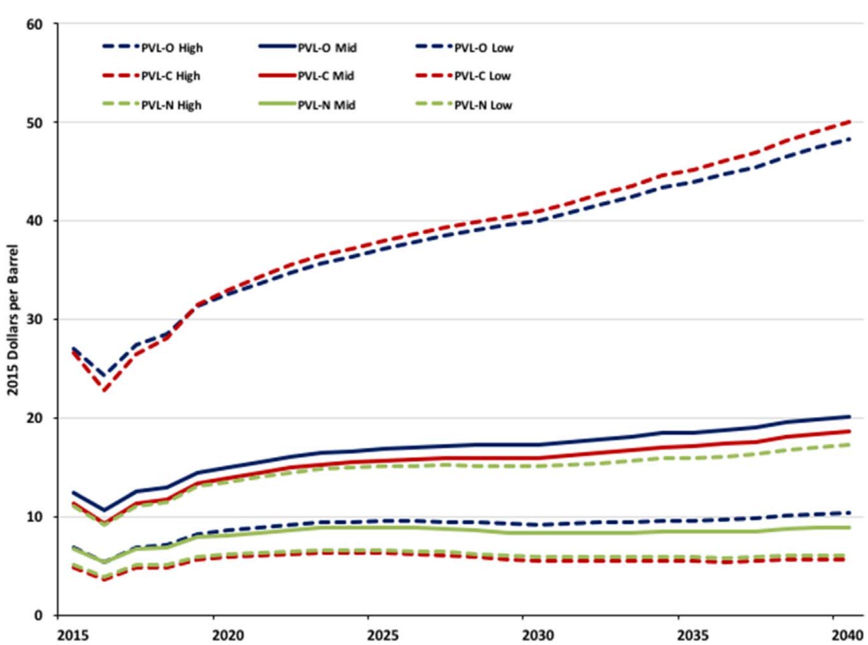

Fig. C.3. Traditional oil premiums for the consumption of imported oil.

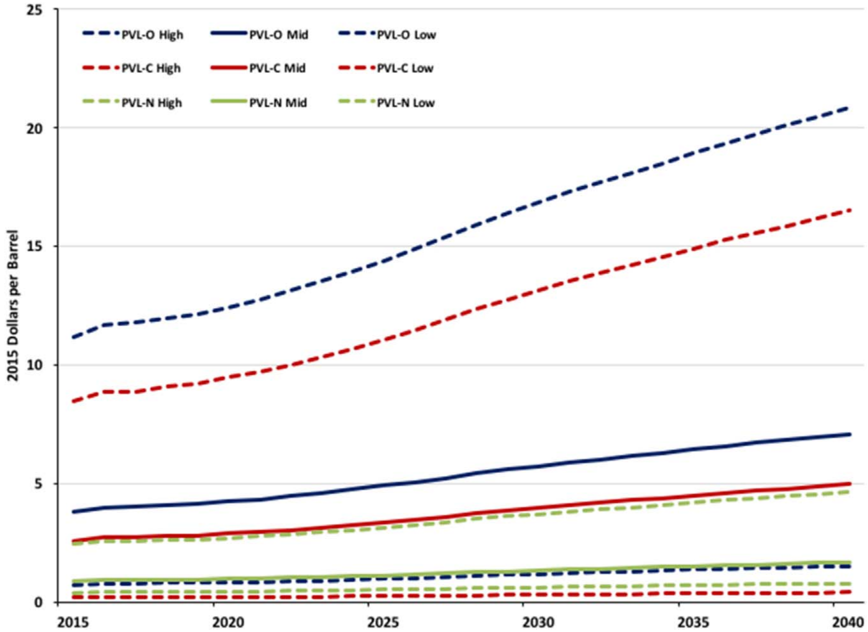

Fig. C.4. Traditional premiums for the consumption of domestic oil.

$1.51–$20.84) in 2040. Under PVL-C, the premium rises from a mid-value of $2.59 per barrel (in a range of $0.18–$8.45) in 2015 to a mid-value of $4.96 per barrel (in a range of $0.40–$16.48) in 2040. Under PVL-N, the premium rises from a mid-value of $0.87 per barrel (in a range of $0.40–$2.43) in 2015 to a mid-value of $1.67 per barrel (in a range of $0.79–$4.62) in 2040.

C.3.3. Traditional premiums for imported vs. domestic oil 2015–2040

As shown in Fig. C.5, the premium for the substitution of imported oil for domestic oil (also known as the traditional oil import premium) increases from 2015 to 2040 for the PVL cases. As shown in the figure, PVL-O finds the premium rising from a mid-value of $8.62 per barrel (in a range of $6.15–$15.86) in 2015 to a mid-value of $13.05 per barrel (in a range of $1.51–$20.84) in 2040. Under PVL-C, the premium rises from a mid-value of $8.70 per barrel (in a range of $4.63–$18.07) in 2015 to a mid-value of $13.68 per barrel (in a range of $5.27–$33.53) in 2040. The mid- and upper values for PVL-C are higher than those for PVL-O because PVL-C finds higher expected transfers on the marginal barrel of oil. Under PVL-N, the premium rises from a mid-value of $5.83 per barrel (in a range of $4.67–$8.62) in 2015 to a mid-value of $7.24 per barrel (in a range of $5.30–$12.60).

C.4. Evaluating policy with the traditional oil premiums

Differences in the traditional oil premiums and the oil security premiums have significant effects on the estimated values. The upper ranges estimated under the traditional oil premium approach, pioneered by Landsberg et al. (1979), finds relatively high costs associated with U.S.

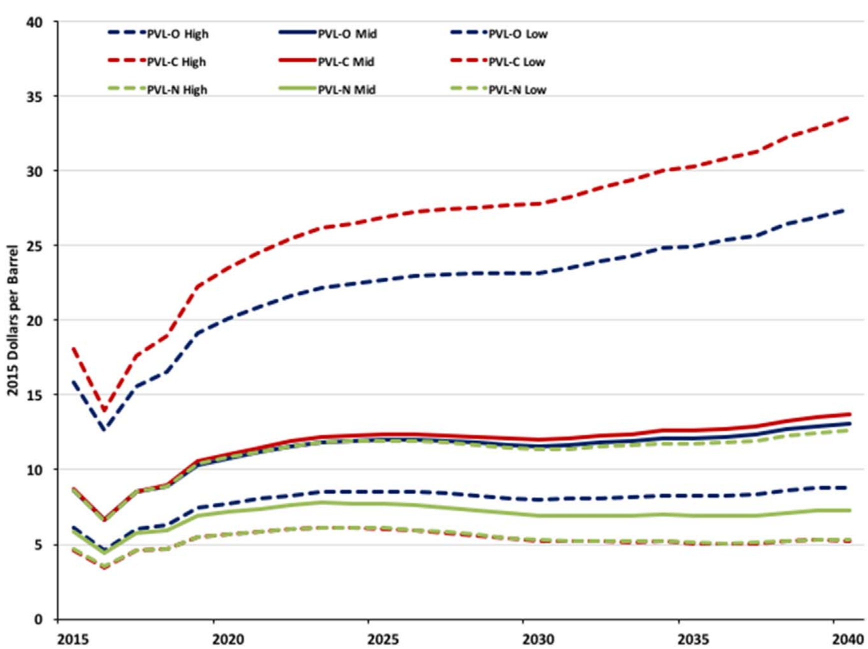

Fig. C.5. Traditional premiums for imported vs. domestic oil.

consumption of imported oil and the substitution of imported oil for domestic oil. Much lower costs are found for U.S. consumption of domestic oil. The mid- and lower ranges found with the narrower oil security measures developed by Brown and Huntington (2013) find only moderate costs associated with U.S. consumption of imported and domestic oil. Much lower costs are found for the substitution of imported oil for domestic oil.

The differing estimates may represent philosophically different approaches to oil security policy. The narrower measures of oil security developed by Brown and Huntington (2013) and used for official U.S. policy keep a sharper focus on how economists define externalities than do the more expansive measures used in the traditional oil premiums. Those who prescribe significant policy interventions to address U.S. reliance on imported oil may be looking beyond standard economic thinking to broader measures of the costs of consuming imported oil that are captured by the traditional oil premiums.

Taken together, the oil security premiums, the traditional oil premiums and the environmental costs of U.S. oil consumption show the possibility for considerable disagreement about the development of U.S. policy toward oil consumption, oil imports and domestic oil production. Policymakers and analysts who favor the traditional oil premium estimates and rely on the upper range of estimates will see U.S. oil security as equally or more important than the environmental costs of oil use. They will also see the cost of U.S. consumption of imported oil as much greater than the use of domestic oil. Those policymakers and analysts who favor the narrower oil security premiums and use the lower ranges of estimates will find that U.S. oil policy ought to focus on the environmental costs of oil use, and they will see little difference in the security costs of using imported or domestic oil.

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