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Abstract

New technologies for accessing energy resources, changes in global energy markets, and government policies have encouraged growth in the natural gas and wind industries in the 2000s. The growth has offered new opportunities for wealth creation in many rural areas. At a local level, households who own land or mineral rights can benefit from energy development through lease and royalty payments. Using nationally-representative data on U.S. farms from 2011, we assess the consumption, investment, and wealth implications of the $2.3 billion in lease and royalty payments that energy companies paid to farm businesses. We estimate that the savings of current energy payments combined with the effect of payments on land values added $104,000 in wealth for the average recipient farm.

JEL Codes: D12, Q12, R11
Key words: energy payments, household, consumption, investment, land values

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INTRODUCTION

In the past decade, energy production has offered new opportunities for wealth creation in many rural areas. Energy from nontraditional sources – especially natural gas from shale and sandstone formations, biomass, and wind energy – account for a growing share of U.S. energy supply. Between 2005 and 2011, more than half of the growth in U.S. primary energy production came from increased natural gas production, and more than one fourth came from biomass (primarily ethanol) and wind energy production combined.[1] Domestic oil production has also seen an increase as the industry has responded to higher crude oil prices by applying drilling innovations to shale oil formations.

Most recent energy development has occurred in rural areas with abundant land for drilling pads and wind turbines. The growth in gas production largely follows the location of unconventional gas formations, covering large rural areas in Colorado and Wyoming in the west, Arkansas, Louisiana, Oklahoma, and Texas in the south-central, and the Appalachian region in the east. Similarly, the Midwest and central parts of the U.S. have the greatest on-shore wind potential, which is where most installations of wind turbines to date have occurred (USDOE 2012). Within areas with the resource potential for energy development, other factors can affect location decisions, including the cost of land and access to infrastructure like gas pipelines, railways, and electrical grids. At a local level, households who own land or mineral rights derive large economic benefits from energy development through lease and royalty payments. However, as household consumption and investment increases, the effects of payments extend beyond the households who receive them.

We focus on natural gas and wind because they generate payments to households who own land (and for gas, mineral rights) where gas is extracted or wind turbines are placed. We first briefly describe the recent growth of the natural gas and wind industries and the broad implications of energy development for different types of local wealth. Then we use nationally-representative data on U.S. farms from 2011 to assess the consumption, investment, and wealth implications of lease and royalty payments from energy companies to farm households and businesses.

EMERGING ENERGY INDUSTRIES – GROWTH AND ITS CAUSES

Shale gas production has grown rapidly from two percent of U.S. natural gas production in 2000 to an estimated 37 percent in 2012 (Mufson 2012). The increase has caused production to reach new historic highs each year since 2007 (EIA 2012). Favorable energy prices in the 2000s and improvements in extractive technology have contributed to the production boom. The refinement of horizontal drilling and hydraulic fracturing ("fracking"), which consists of injecting a mix of water, chemicals, and sand into wells to create fissures in rock formations, has improved the profitability of extraction. Consequently, drilling has expanded across the U.S.

State governments have encouraged development to varying degrees, with substantial variation in taxation and regulation of drilling across states (Resources for the Future 2012). Environmental concerns have led the state of New York to place a moratorium on fracking. By contrast, the Pennsylvania legislature has encouraged drilling by not taxing extraction, though it has recently assessed an impact fee on wells. A potentially more important deterrent is the fall in natural gas prices from growth in supply; greater production has already dramatically lowered natural gas prices in the United States (MIT 2011).

From 2007 to 2010, wind energy contributed 36 percent of all new electric generation capacity added to the U.S. power system (Wiser and Bollinger, 2011). By 2010, installed wind power capacity could provide more than 5 percent of total electricity supply in 13 states, with four states above 10 percent (Iowa, Minnesota, North Dakota, and South Dakota).

Supportive policies have spurred growth in wind energy, including the federal production tax credit, the Rural Energy for America Program, state renewable energy portfolio standards, and financial incentives by state and local governments (Bird et al. 2005; Lu et al. 2011). The American Recovery and Reinvestment Act of 2009 also included investment tax credits and grants for community wind investors. Other causes of growth include higher energy prices and public support for renewable energy (ELPC 2009).

IMPLICATIONS FOR DIFFERENT TYPES OF WEALTH

In a broad sense, extracting natural gas or harnessing wind for electricity involves converting a stock of natural capital into a flow of marketable goods. In addition to wind or gas endowments, the conversion draws upon stocks of multiple types of capital. Focusing on natural gas, extraction draws on human, physical, natural, and even social capital.

Initially most natural gas workers and supporting firms come from outside the drilling area, especially in areas that have historically produced little gas and therefore have few workers with industry experience. Over time, however, local firms and residents tend to supply more labor and services. In the initial stages of exploration of the Marcellus Shale, roughly 70 percent of gas company employees came from out of state; by 2010 the situation had reversed, with in-state employees accounting for 70 percent (Marcellus Shale Education and Training Center 2011).

Large-scale extraction also requires public infrastructure to access drilling sites (public physical capital, water for fracking (natural capital), and treatment and storage options for waste (potentially a mix of physical and natural capital). Drilling one gas well in shale can involve up to a thousand truckloads of equipment and materials (National Park Service 2009). It also requires between two and ten million gallons of water (Kargbo, Wilhelm, and Campbell 2010). Extraction also depends in part on social capital as represented by trust or the lack therefore between residents and the industry. In states like Texas and Louisiana, which have a long history of energy development, fracking has met little local opposition compared with New York, which does not have such a history.

Converting gas endowments into marketable gas generates payments for labor employed in the industry, for landowners with mineral rights, and for governments through tax revenues. Payments to labor can be substantial. One study found that counties experiencing a boom in gas production in Colorado, Texas, and Wyoming saw wage and salary income increase by $69 million over the growth period (Weber 2012). Extraction also generates billions of dollars in payments to landowners and in tax revenues for state and local governments.

The long-term implications of gas development on local wealth depend on the industry's direct effect on local capital (e.g. roads or air quality) and on how workers, landowners, and government use income from development. The two effects are tightly connected. If saved, income from development will form part of the stock of financial capital that residents can channel into other types of capital. The incentive for residents to invest locally, however, depends on how gas development affects the area's physical and natural capital. A decline in property values near drilling areas, which has been observed in some areas, reflects perceived health risks or deterioration of infrastructure, landscape aesthetics, or groundwater quality from drilling (Boxall et al. 2005; Muehlenbachs et al. 2012; Hill 2012). This in turn reduces the incentive for residents to invest locally in residential property development, for example, or in starting a new business that serves the local market.

On the other hand, revenue generated by production and invested in schools, roads, and public recreational infrastructure can complement and stimulate local private investment. Furthermore, where gas development has not changed the returns to investment, payment streams may finance greater investment: some evidence suggests that farmers have used royalty payments to improve their operations (Kelsey et al. 2011).

Similar to natural gas development, local endowments of several types of wealth are likely to affect and be affected by wind power development. Wind development has principally drawn upon a region's wind resource, land (natural capital), and access to electrical transmission lines (physical capital). Compared to natural gas, wind energy has little effect on natural capital like air and water quality. The interruption of the landscape by wind turbines is probably the most salient disamenity associated with wind energy.

Little is known about the impacts of wind power development on local wealth. A recent econometric study of local economic impacts of wind power development estimated that wind power was associated with about $11,000 of additional annual personal income and 0.5 of additional jobs per megawatt of wind power capacity installed (Brown et al. 2012). Some communities have invested wind dollars in education. One school district in West Texas reported that by the 2018-19 school year, it will have received about $35 million from a wind farm company in 2005 (New York Times 2011).

In the long term, the eyesore of wind turbines may reduce peoples' desire to live, visit or work in the community, in turn affecting migration, commuting flows, income from tourism, with subsequent potential impacts on property values and tax revenues (Hoen et al. 2009;

Heintzelman and Tuttle 2011). Opposition to wind turbines in some areas suggests that some people strongly prefer to not have wind turbines interrupting the horizon. Examples include opposition to proposed off-shore wind turbines in Cape Cod, Massachusetts (Levitz 2012) and to the first community-based wind project in Utah (Hartman et al. 2011).

The long-term local effects from energy development are unknown and complex. To better understand the complexity, a flow diagram (figure 1) shows the various potential factors and local actors involved with energy development. Market forces, government polices (federal, state, and local), and stocks of local wealth influence energy development. Owners of land and mineral rights receive energy payments, which in turn affect property values. Thus, payments have a direct effect on income and wealth, both of which influence consumption, savings, and investment.

[figure 1]

ENERGY PAYMENTS TO FARM HOUSEHOLDS AND BUSINESSES

As mentioned earlier, natural gas and wind development generate lease and royalty payments to many farm households and businesses. Although some public subsidies exist for operators of wind turbines, we use “energy payments” to refer to the payments from private energy companies or brokers to owners of surface or mineral rights. For oil and natural gas, the payments represent the conversion of a *stock* of a nonrenewable natural resource into cash. For wind the payments represent the conversion of a *flow* of a renewable resource into cash. The differences suggest that wind has a greater potential to support long-term wealth accumulation. Despite their potentially different effect on wealth, we study the two types of payments together, largely because only 49 of the 426 (unweighted) respondent farms with payments were associated with wind. However, in the empirics on land values we estimate the model with and without farms with wind payments.

Typical leases for natural gas are for five years with royalty payments of 12.5 percent of the value of gas removed. Often one-time bonus payments are made to landowners upon signing a lease. Leases can also specify a delay rental paid based on the time lapse between signing the lease and when development occurs. Wind leases are more long term at 20 to 25 years with different combinations of annual payments ranging between $4,000 to $8,000 per turbine and royalty payments of three to six percent of gross revenues (PSU 2009; Aakre and Haugen 2010). Of course, typical payments can vary over time with market conditions and from landowner to landowner based on bargaining power and parcel attributes. There are three common types of wind lease payments; fixed annual payments, electricity production royalties, and a combination of the two (Windustry 2005). Fixed annual payments involve the least risk but may be unattractive in areas with high wind potential and consequently greater upside potential from more productive turbines.

Companies drilling in the Marcellus shale in Pennsylvania in 2008 paid landowners two billion dollars in 2008 (Considine et al. 2009). Those drilling in the Haynesville shale in Louisiana reported paying 1.2 billion dollars in 2009 (L.C. Scotts and Associates 2009). Because the jobs from energy development are likely short lived, what households do with the payments will play a large role in shaping the long-term effects of energy development on producing regions.

There is no nation-wide source of information on energy payments and the households who receive them. However, in 2011 the Agricultural Resource Management Survey (ARMS)–a nationally representative survey of farm businesses and the households who operate them– included for the first time a question on lease and royalty payments from energy activities.[2] Specifically, the question asked for "income from royalties or leases associated with energy production (*e.g. natural gas, oil, and wind turbines*)."

Much of the existing information on rural wealth focuses on farms (Pender, Marré, and Reeder 2012). Farm households generally differ from nonfarm rural households, especially in terms of wealth. However, the majority of rural households own little land and are therefore not in a position to receive energy payments. Landlords who do not operate farms own about 42 percent of U.S. farmland. Of them, 85 percent live less than 150 miles from the land they own, suggesting that most of them are residents of rural areas (U.S. Department of Commerce 1993). Unfortunately, there is a dearth of information on non-operator landlords. Although data on payments to landowning households in general would be nice, payments to farms merit attention because they shed some light on payments to landowning households in general. Payments to the two groups likely differ only to the extent that they lease different quantities of land to energy developers and therefore receive different total payments.

Another advantage of looking at farm households is that many of them run a business – a farm. (Admittedly, only 42 percent of farms are labeled a farm business by the USDA in that they have at least $250,000 in sales or the principal operator defines farming as his or her primary occupation). This allows us to study one dynamic channel through which energy development affects rural wealth – the conversion of natural capital into financial capital (payments), which the farm household may then turn into physical capital (equipment) to improve the profitability of their farm business and their accumulation of wealth. The ARMS is well-suited for such an endeavor. Its detailed information on the household of the farm's principal operator, including consumption expenditures and nonfarm assets, liabilities, and income, permit researching household responses to payments. Furthermore, the ARMS is nationally representative, allowing us to draw conclusions about the frequency and magnitude of energy payments to farms in the entire lower 48 states.

In 2011 an estimated 3.4 percent of all farms, roughly 74,000 farms, received lease or royalty payments from energy activities. In line with the magnitude of payments suggested by the previously mentioned studies, payments to farms were economically significant–totaling $2.3 billion. By comparison, 35 percent of farms received some type of farm program payments from the Federal government. However, payments from the single largest farm program, direct payments, only totaled around $5 billion per year under the 2008 Farm Act. From 2008 to 2011, all government payments, including crop insurance and conservation payments, averaged $11.8 billion a year (USDA-ERS, 2012a). Thus, energy payments are about half of direct payments and 19 percent of the total Federal government support to farms. Furthermore, the median government payment was $3,642 while the median energy payment was $7,000, with a quarter of farms receiving $25,000 or more (table 1).

The geography of energy payments is also distinct from that of Federal farm program payments. Energy payments are concentrated in the Plains region as shown in Table 2. Farm program payments are highest in the Midwest and Plains but are more uniformly distributed across regions. Because of the concentration of energy payments in the Plains, many of them go to livestock producers, with roughly half of farms receiving energy payments specialized in raising beef cattle. In contrast, crop farms are more likely to receive farm program payments (White and Hoppe 2012).

[tables 1 and 2]

Economic theory has various frameworks of consumer behavior that help explain household consumption decisions. Traditional theories of consumption, such as the life-cycle model, use the permanent income hypothesis to argue that households smooth consumption over their life cycle and base consumption on their total lifetime income (Friedman 1957; Ando and Modigliani 1963). A more behavioral framework hypothesizes that economic agents categorize income into separate “mental accounts” according to rules of thumb (Thaler 1985; Sheffrin and Thaler 1988). For example, consumers may spend a larger percentage of income streams if they view them as more permanent versus transitory sources. Similar to Whitaker (2009), we use an adaptation of the life-cycle model proposed by Carriker et al., 1993, which allows for differing marginal propensities to consume across income sources. The model essentially combines the underpinnings of the life-cycle and behavioral frameworks to explain household consumption.

Under perfect capital markets, the optimal investment by households in their farm depends on the price of capital and the profitability of the farm investment. If households are credit constrained in some way, perhaps because of insufficient collateral, the household will have to finance investment out of its own resources, including income and wealth from all sources. There is evidence of credit constraints for some U.S. farms (Briggeman, Towe, and Morehart, 2009). We therefore estimate a farm investment model using the same income and wealth variables as in the household consumption model.

There are two main channels through which energy payments and the activities that generate them can affect the wealth of recipient households. First, payments may be saved, in which case they form part of the household’s wealth. Second, the capitalization of payments or any amenities or disamenities created by energy development will affect the value of the household's landholdings and therefore their wealth.

The implications of payments and energy activities on rural wealth extend beyond their direct effects on the wealth of recipient households. Consumption of payments or their capitalized value in land will increase the sales of local businesses, to the extent that households consume local goods and services. Prior research has suggested that 50 to 60 percent of farm business expenditures are spent locally (Foltz and Zeuli 2005; Lambert et al. 2009). Farmers in more urban areas tend to purchase household items closer to home, but travel longer distance to purchase farm business items (Lambert et al. 2009). In more rural locations, the opposite pattern has been observed (ibid).

Outside of increasing revenues and profits of local businesses, consumption of payments implies a short-lived effect on economic well-being and a negligible effect on wealth. If used to buy financial assets such as stocks, payments will likely generate wealth in line with market rates of return but have little influence on the local economy. The influence would be greater if instead households invested in their farm or other ventures that employ people or purchase materials from local businesses. Households may expand an existing business or start a new one if payments allow them to overcome financing constraints. Similarly, if household borrowing costs depend on wealth and the net effect of energy development is to increase land values then higher land values would lower the cost of capital and potentially make some previously unprofitable ventures profitable.

We use the 2011 Agricultural Resource Management Survey (ARMS) to explore three empirical questions:

1. How much of each energy payment dollar is consumed?

2. Are payments associated with greater farm investment?
3. Are payments associated with higher land values?

In all the empirical models we take energy payments to be exogenous. The option to lease land for energy developers is likely determined by long-established geological characteristics. It's also unlikely that the farmer would have chosen where to farm based on the potential for energy payments. Leasing land, however, is clearly a choice of the farm operator and may be related to unobserved farm characteristics. This is most likely an issue with payments and land values, since the quality of the land may influence the decision to allow energy development – a possibility whose implications we discuss in that section.

How much of each energy payment dollar is consumed?

Here we estimate how much of each energy payment dollar received by farm households is consumed in the year received. We assume that households consume out of their current income and wealth, and that they may have different propensities to consume out of different types of income and wealth. Whitaker (2009) estimated the propensity for U.S. farm households to consume out of different types of income. We estimate a similar model:

$$(1)\ C_{i,t} = \alpha + \beta_j \sum Y_{i,t}^{j} + \delta_f W_{i,t}^{f} + \delta_{nf} W_{i,t}^{nf} + \gamma_1 Age_{i,t} + \gamma_2 Age_{i,t}^{2} + \epsilon_{i,t},$$

where $C_{i,t}$ represents household *i*'s consumption expenditures in period *t*, $Y_{i,t}^{j}$ denotes income for household *i* from source *j*, $W_{i,t}^{f}$ and $W_{i,t}^{nf}$ are the household's farm and nonfarm net worth, and $Age_{i,t}$ is the age of the farm's principal operator. Separating income by its source allows for the possibility that income streams are not perfect substitutes for each other (Carriker et al. 1993).

We include four types of income: energy payment income, net farm income (including government payments), and earned and unearned off-farm income. We also separate total net worth (household assets minus debt) into farm and nonfarm wealth. We account for life cycle effects by including the age and age-squared of the principal operator of the farm.

An implication of the permanent income hypothesis is that the more transitory the income, the less inclined households are to consume it (Friedman, 1957). Whitaker (2009) found that farm households consume more out of direct government payments, which are fixed in the medium term, than out of counter cyclical or loan deficiency payments that vary from year to year based on market prices. Similarly, he found that households consumed 10 cents of every dollar of off-farm income but only one cent of every dollar in net farm income. Recent estimates on households' marginal propensity to consume in the U.S. range between 0.10 and 0.40 (Gross and Souleles 2002; Shapiro and Slemrod 2003, 2009; Johnson et al. 2006; Agarwal et al. 2007). Measures of wealth are often not included in the model specification of these prior studies suggesting that the estimated marginal propensities to consume out of income might be lower if wealth were included. However, Whitaker's relatively low propensities to consume are not an anomaly. Carriker et al. (1993) estimated a similarly small marginal propensity to consume farm income for a panel of Kansas farm households: each dollar in adjusted net farm income increased consumption by just 2.6 cents.

It is unsurprising that the marginal propensity to consume income is lower for farm households than for U.S. households in general. Johnson et al. (2006) found that households with more liquid assets consumed less of their tax rebates. This is important because 96 percent of farm households have more wealth than the median U.S. household (USDA-ERS 2012b). Similarly, Jones, Milkove, and Paszkiewicz (2010) find that on average farm households consume substantially less of their income than U.S. households. Their study explores consumption patterns using data from the Agricultural Resource Management Survey and the Consumer Expenditure Survey. Both surveys showed that on average farm households consumed 57 percent of their income. In contrast the Consumer Expenditure Survey showed that nonfarm households consumed 71 percent of their income.

We estimate the consumption model for all farm households and then for a sample trimmed in two ways. Because of uncertainty regarding how energy payments to the farm business are allocated when multiple households share in net farm income, we drop observations where more than one household shares in the income. We also trim households who rent their dwelling to avoid inappropriate comparisons. In many cases the farm businesses owns the house of the farm household. Expenses associated with the house are therefore paid for in the form of lower net farm income to the household. We do not attempt to value housing consumed by the households. But for the few households who rent their dwelling, their rental expense is included in consumption expenditures, which is why we drop them.

When we look at all farm households we find a statistically insignificant effect of energy payments on household consumption. Excluding cases where multiple households share in income from the farm and where the household rents its dwelling reduces the point estimate, but it reduces the standard error even more so, leading to a statistically significant relationship at the five percent level. The estimates of the coefficients on the other variables change little.

Each dollar in energy payments is associated with 4.2 cents of additional consumption expenditures, below the estimate for off-farm income (5.9 cents) but much larger than that of net farm income (0.70 cents). Earned off-farm income is largely from wages and salaries and is arguably the most stable income for many farm households. The finding that energy payments are more likely to be consumed than farm income but less likely to be consumed than earned income suggests that they perceive energy payments as moderately stable income. The stability of payments of course rests largely on the details of the leases with energy companies and the energy source. One interpretation of our findings is that on average the leases are specified so as to provide households with relatively consistent payments.

The estimate for farm income and earned income are in line with prior studies of U.S. farm households (Carriker et al., 1993; Whitaker 2009), but are lower than estimates for U.S. households in general. This is expected for the reasons mentioned earlier, such as the dramatically greater wealth of farm households. On the other hand, estimates for the propensity to consume out of nonfarm net worth are similar to prior estimates for U.S. households. For each dollar in nonfarm wealth, farm household consumption increases by 0.019. Estimates for U.S. households have been around 0.02 (Levin 1988; Bostic et al. 2009). In contrast, farm households have a much lower propensity to consume out of farm net worth (0.001), which likely reflects its illiquid nature.

One reason to expect a lower propensity to consume farm income is the recent increase in the amount of capital purchases that can be expensed in the year purchased. Large depreciation expenses imply that a farm household that experienced strong cash income from farming would show a low net farm income. A household that experienced a similarly strong cash income from farming but that did not make a capital purchase would have a higher net farm income. Despite the different net farm incomes, which is what is measured by our farm income variable in the empirics, the two households would likely have similar consumption, thereby lowering the coefficient estimate for farm income.

Are payments associated with greater farm investment?

Few researchers have studied how additional income to the farm household affects farm investment. If the farm household has limited access to credit, then an income windfall should lead to greater farm investment. Earlier work on farm investment looked at how changes in tax policies affected investment (LeBlanc and Hrubovak 1986; LaDue et al. 1991; LaBlanc et al. 1992; Jensen et al. 1993). More recently, others have investigated the linkages between off-farm income sources and off-farm investment by farm households (Mishra and Morehart 2001; Mishra et al. 2002).

We assume that household consumption and investment decisions depend on each other and are therefore influenced by the same factors. Consumption and investment decisions may affect each other if farm households are forced to self-finance investment because of imperfect credit markets. The equation we estimate has the same specification as in (1) but with farm investment as the dependent variable. We define farm investment as the sum of capital expenses made in the survey year, including purchases of or improvements to land (e.g. drainage tile, manure lagoons), construction of buildings, and the purchase of vehicles, tractors, or equipment.

On average, a dollar in energy payments was associated with 10 cents in farm investment, but the estimate was statistically insignificant. Unlike with consumption, excluding farm businesses with multiple households has almost little effect on the point estimate or its precision. The imprecision partly reflects the small number of households in the ARMS Version 1 sample with energy payments (less than 400). In the future a larger sample from pooling multiple years could give a more precise estimate.

[table 3]

Are payments associated with higher land values?

Prior research has showed that farm program payments are capitalized in land values (Weersink et al. 1999; Shaik et al. 2005; Goodwin et al. 2011). There may be a similar capitalization of energy payments, particular if most farms own the rights to the minerals below their land. On average energy payment farms received 40 dollars per acre in 2011. The ARMS asks farmers how much land they own and its estimated value, excluding the value of any buildings or perennial crops. To explore whether the payments are associated with higher land values we estimate

$$(2)\ V_i = \alpha + \gamma_1 E_i + \gamma_2 A_i + \gamma_3 G_i + X_{i,k}\beta_k + State_i + \varepsilon_i,$$

where *V* is the total value of land owned by the farm business, *E* is the energy payment received, *A* is the number of acres owned, *G* is the value of direct payments received, and *X* is a vector of factors influencing farm land values, and *State* is a dummy variable for the state. The vector includes variables related to land quality and urban influence (Plantinga et al., 2002). To control for land quality, we include dummy variables for the farm's land resource region (there are twenty such regions in the U.S.) and the percent of the county's total area in each land capability class as defined by the National Resource Conservation Service. Also somewhat related to land quality is the farm's production specialty as defined by the commodities that make up the majority of its sales, which we also control for. To capture the effect of local demand and urban influence, we include the median household income of the county and a linear and quadratic term for the driving time to the nearest city of 250,000 or more.

We note that unlike the first two sets of results, which used the household as the unit of analysis, the land value model is based on farm businesses. The practical difference is that all farm businesses includes nonfamily farms, where 50 percent or more of the farm is owned by people who are not related.

Because the specificiation in (2) holds total acres constant, the coefficient on energy payments has the same interpretation as if all the variables were in per acre terms.[3] Consequently, $\gamma_1$is the   the per acre increase in land values associated with an additional dollar per acre in energy payments. We find that each dollar in energy payments is associated with $2.6 dollars in additonal value of an acre of land. Unlike natural gas or oil leases, where the norm is for the entire property to be leased, wind payments are often for use of only a few acres of the farm. We therefore estimate the model excluding farms receiving wind payments. Doing so gives a similar coefficient estimate but as smaller standard error. Because energy development may affect land values for farms not receiving payments, we also estimate the model excluding farms that did not receive a payment but were in a county where at least half of the county covered an unconventional oil or gas formation. Again, doing so gives very similar estimates (not shown).

By comparison, each dollar in direct government payments is associated with about $35 dollars in land value. Prior estimates of capitalization of farm program payments in land values using ARMS have ranged from almost nothing to roughly thirty dollars an acre (Goodwin et al., 2003a; 2003b; 2011). Care is needed when interpreting the estimates. Direct payments are based on historic yields, meaning that more productive land receives higher payments. Because more productive land is also worth more, the true effect of direct payments on land values is likely smaller than what we have estimated. For energy payments the bias likely works in the other direction. Farmers with marginal land are perhaps more likely to lease land for energy development, meaning that the true effect of energy payments on land values may be higher.

Taking the point estimate of 2.6 as a lower bound, it suggests that farmers expect payments to dissipate quickly over the ensuing years. (At a five percent discount rate, the discounted value of a dollar paid in each of the next three years is about $2.70). This is roughly consistent with evidence that production from natural gas declines exponentially as the well ages (MIT 2011). An alternative interpretation is that energy development makes the land less desirable for other uses. A well pad may make the parcel less attractive for residential development since people probably prefer to see a pristine landscape instead of one dotted with tanks, tubes, and concrete slabs. They may also be concerned about effects on well water. Thus, the expected flow of energy payments may be large but is partially offset by disamenities associated with wells or turbines.

[table 4]

Total Effects on Consumption and Wealth

In our consumption model we estimated the effect of current payments on consumption. Taking the total derivate of (1) with respect to energy payments (and assuming that payments have no effect on operator age, and farm and nonfarm income) gives

(3) $$\frac{dC}{dE} = \frac{dC}{dE}\frac{dE}{dE} + \frac{dC}{dW_{nf}}\frac{dW_{nf}}{dE} + \frac{dC}{dW_f}\frac{dW_f}{dE}$$

where *W* denotes wealth and *f* and *nf* denote farm and nonfarm. We directly estimated $\frac{dC}{dE} = \beta_E$, $\frac{dC}{dW_{nf}} = \delta_{nf}$, and $\frac{dC}{dW_f} = \delta_f$ in equation 1. Although we do not directly estimate the effect of energy payments on nonfarm wealth we approximate it by assuming that all energy payments not consumed or paid in taxes form part of nonfarm wealth. We suppose a tax rate of 20 percent. On average farm proprietors paid an effective income tax rate of 15 percent in 2010 (Williamson, Durst, and Farrigan, 2013). We add another five percent to account for any state and local taxes. Using τ to refer to taxes paid on energy payments, each dollar in energy payments adds $1 - \tau - \beta_E$ to nonfarm wealth. This assumes that energy payments are not saved as farm wealth, which although unrealistic, may be a good approximation given the statistically insignificant effect of energy payments on farm investment. Energy payments, however, affect farm wealth by affecting land values. We assume that $\frac{dW_f}{dE} = \gamma_1$, with γ_1 coming from estimating equation 2. The total consumption effect of the 2.3 billion in energy payments is then:

(4) $\Delta C = \frac{dC}{dE}E = \beta_E E \ + \delta_{nf}(1 - \tau - \beta_E)E + \delta_f \gamma_1 E$

where the last two terms reflect the effect of payments on consumption via wealth and the $\beta_E E$ term captures the direct effect of payments on consumption.

We estimate that the \$2.3 billion in energy payments to farm businesses and households would stimulate \$140 million in consumption in the year paid, most of which corresponds to consumption of current payments as opposed to consuming the wealth created by the capitalization of expected payments into land values (table 5).

The components of equation (4) allow us to calculate a total wealth effect, from saving energy payments and from payments affecting land values.

$$(4)\ \Delta W = (1 - \tau - \beta_E)E + \gamma_1 E$$

The first term on the right hand side equals 1.74 billion dollars; the second term, \$5.98 billion dollars. With roughly 74,000 farms receiving payments, the total effect implies an average wealth effect of about \$104,000 per recipient farm, or about five (ten) percent of the average (median) recipient farm wealth. This is the current wealth effect from saving current energy payments and the effect of future payments (and the activity that generates them) on land values. It is not an annual flow: presumably payments in the following year would be associated with a small decline in land values since the resource stock has declined, at least in the case of natural gas and oil.

[table 5]

CONCLUSION

New technologies for accessing energy resources, changes in global energy markets, and government policies at all levels have influenced energy development in the 2000s. Local wealth endowments – particularly of natural resources, but also of human, physical, and other types of capital – have affected where development has occurred. Energy development in turn has affected local wealth endowments by creating income and government revenue that can be invested locally or by affecting natural amenities or social capital.

We highlight several observations from our look at energy payments. First, there is potential for the distribution of costs and benefits of energy development and energy payments to undermine social capital in a community. Energy payments are substantial – 15 percent of farms receiving payments received more than $50,000 – but are concentrated among few farms. The same is likely true for landowning households in general. Moreover, only a minority of rural households own much land. Rural residents without land or mineral rights may benefit from development in other ways (employment, for example), but many will have to bear greater congestion on the roads or the unwanted view of wind turbines in the horizon without receiving much benefit. The uneven distribution of costs and benefits could cause tension between neighbors as some work ardently to limit energy development while others welcome it.

Second, the effects of energy development on public and private wealth may be quite different. We estimate that energy payments added about $104,000 on average to the net worth of farm households receiving payments. But energy development, especially for natural gas, uses public infrastructure and potentially degrades natural assets. With natural gas, it's unclear if public revenues generated by the industry offset the depreciation of public physical and natural assets. The same concern may apply to wind: although it has fewer public costs, many local and state governments have given the industry favorable tax treatment.

Third, because real estate accounts for a large share of the asset portfolios of many rural households (as with U.S. households in general), the largest effect of energy development on private wealth will likely come through property values. In our study, higher land values accounted for roughly three-quarters of the total estimated private wealth effect. The estimated effect may mask two competing effects – the positive effect of payments on land values and the negative effect from any deterioration of local amenities such as water quality, scenic beauty, and infrastructure. If so, properties adjacent to areas with energy development but without payments could decline in value. In time, even properties that receive payments may depreciate as payments decline and any disamenities created from development persist or worsen (e.g. failure of cement casing in older wells causing gas to enter well water). Clearly, there are important spatial and temporal questions regarding property values where empirical research is needed. Thus, this study is only a small step towards further understanding the consequences of energy development on rural wealth and economic well-being.

References

Aakre, D., Haugen, R. 2010. Wind Turbine Lease Considerations for Landowners. http://www.wind-watch.org/documents/wind-turbine-lease-considerations-for-landowners/

Agarwal, S., Liu, C., Souleles, N.S. 2007. **"**The Reaction of Consumer Spending and Debt to Tax Rebates—Evidence from Consumer Credit Data." *Journal of Political Economy* 115: 986-1019.

Ando, A., and Modigliani, F. 1963. The 'Life Cycle' Hypothesis of Saving: Aggregate Implications and Tests. *American Economic Review* 53(1): 55–84.

Bird, L., Bolinger, M., Gagliano, T., Wiser, R., Brown, M., & Parsons, B. (2005). Policies and market factors driving wind power development in the United States. *Energy Policy, 33*(11), 1397-1407.

Bostic, R., Gabriel, S., and Painter, G. 2009. "Housing wealth, financial wealth, and consumption: New evidence from micro data." *Regional Science and Urban Economics* 39(1): 79-89.

Boxall, P.C., Chan, W.H., & McMillan, M.L. 2005. The impact of oil and natural gas facilities on rural residential property values: A spatial hedonic analysis. *Resource and Energy Economics 27*, 248-269.

Briggeman, B.C., Towe, C.A., and M.J. Morehart. 2009. Credit Constraints: Their Existence, Determinants, and Implications for U.S. Farm and Nonfarm Sole Proprietorships. *American Journal of Agricultural Economics*, 91(1), 275-89.

Brown, J.P., Pender, J., Wiser, R., Lantz, E., & Hoen, B. (2012). Ex post analysis of economic impacts from wind power development in U.S. counties. *Energy Economics*, 34(6): 1743-1754.

Carriker, G.L., M.R. Langemeier, T.C. Schroeder, and A.M. Featherstone. 1993. "Propensity to Consume Farm Family Disposable Income from Separate Sources." *American Journal of Agricultural Economics* 75(3): 739-744.

Considine, Timothy J., Robert Watson, Rebecca Entler, and Jeffrey Sparks (2009) "An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play." University Park, PA: The Pennsylvania State University, Dept. of Energy and Mineral Engineering. August.

Energy Information Administration. 2012. "Natural Gas Gross Withdrawals and Production." Available at http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_NUS_m.htm

Environmental Law & Policy Center. (2009). *Community wind financing*. http://elpc.org/wp content/uploads/2009/11/ELPC-Community-Wind-Book-09.pdf

Foltz, J.D. and Zeuli, K. 2005. "The role of community and farm characteristics in farm input purchasing patterns." *Review of Agricultural Economics* 27(4): 508-525.

Friedman, M. 1957. *A Theory of the Consumption Function*. Princeton: Princeton University Press.

Goodwin, B.K., Mishra, A.K., Ortalo-Magné, F., 2011. "The Buck Stops Where? The Distribution of Agricultural Subsidies." National Bureau of Economic Research.

Goodwin, B.K., Mishra, A.K., Ortalo-Magné, F.N., 2003a. "Explaining regional differences in the capitalization of policy benefits into agricultural land values." In: Moss, C.B., Schmitz, A. (Eds.), *Government Policy and Farmland Markets*. Wiley Online Library, pp. 97-114.

Goodwin, B.K., Mishra, A.K., Ortalo-Magné, F.N., 2003b. "What's wrong with our models of agricultural land values?" *American Journal of Agricultural Economics* 85, 744-752.
Gross, D.B., Souleles, N.S. 2002. Do Liquidity Constraints and Interest Rates Matter for Consumer Behavior? Evidence from Credit Card Data. *Quarterly Journal of Economics* 117(1): 149-185.
Hartman, C. Stafford, E. Reategui, S. 2011. Harvesting Utah's Urban Winds. *Solutions* 2(3) http://www.thesolutionsjournal.com/node/930
Heintzleman, M.D., Tuttle, C.M. (2011). *Values in the wind: A hedonic analysis of wind power facilities*. http://ssrn.com/abstract=1803601
Hoen, B., Wiser, R., Cappers, P., Thayer, M., & Sethi, G. (2009). The impact of wind power projects on residential property values in the United States: A multi-site hedonic analysis. Lawrence Berkeley National Laboratory, LBNL-2829E. http://eetd.lbl.gov/ea/ems/reports/lbnl-2829e.pdf
Jensen, F.E., J.S. Lawson, and L.N. Langemeier.1993. "Agricultural Investment and Internal Cash Flow Variables." *Review of Agricultural Economics* 15(2): 295-306.
Johnson, D.S., Parker, J.A., Souleles, N.S. 2006. "Household Expenditure and the Income Tax Rebates of 2001." *American Economic Review* 96(5): 1589-1610.
Jones, C., Milcove, D., Paszkiewicz, L. 2010. Farm Household Well-Being Comparison Consumption- and Income-Based Measures. USDA-ERS Economic Research Report 91.
Kargbo, D.M., Wilhelm, R.G., & Campbell, D.J. (2010). Natural gas plays in the Marcellus Shale: Challenges and potential opportunities. *Environmental Science and Technology*, 44, 5679-5684.
Kelsey, T.W., Shields, M., Ladlee, J.R., & Ward, M. (2011). *Economic impacts of Marcellus Shale in Pennsylvania: Employment and income in 2009*. Marcellus Shale Education and Training Center.
LaDue, E.L., L.H. Miller, J.H. Kwiatkows.1991. "Investment Behavior and Farm Business Expansion." *Review of Agricultural Economics* 13(1): 73-84.
Lambert, D., Wojan, T., and Sullivan, P. 2009. "Farm business and household expenditure patterns and local communities: Evidence from a national farm survey." *Review of Agricultural Economics* 31(3): 604-626.
LeBlanc, M., J. Hrubovak, R. Durst, R. Conway. 1992. "Farm Machinery Investment and the Tax Reform Act of 1986." *Journal of Agricultural and Resource Economics* 17(1): 66-79
LeBlanc, M. and J. Hrubovak. 1986. "The Effects of Tax Policy on Aggregate Agricultural Investment." *American Journal of Agricultural Economics* 68(4): 767-777.
Levin, L. 1988. "Are assets fungible?: Testing the behavioral theory of life-cycle savings." *Journal of Economic Behavior & Organization* 36(1): 59-83.
Levitz, J. 2012. "Cape Cod Wind Farm Tiptoes Ahead." *The Wall Street Journal*, August 10. http://online.wsj.com/article/SB10000872396390444900304577581460741815638.html
Lu, X., Tchou J., McElroy M., & Nielsen, C. (2011). The impact of Production Tax Credits on the profitable production of electricity from wind in the U.S. *Energy Policy, 39*(7), 4207-4214.
MIT - Massachusetts Institute of Technology. 2011. "The Future of Natural Gas". Available at http://mitei.mit.edu/system/files/NaturalGas_Report.pdf
Mishra, A.K. and M.J. Morehart. 2001. "Off-Farm Investment of Farm Households: A Logit Analysis." *Agricultural Finance Review* 61(1): 88-101.

Mishra, A.K., H.S. El-Osta, M.J. Morehart, J.D. Johnson, and J.W. Hopkins. 2002. "Income, Wealth, and the Economic Well-Being of Farm Households." Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 812.

Muehlenbachs, L., Spiller, E., & C. Timmins. 2012. Shale Gas Development and Property Values: Differences across Drinking Water Sources. No. w18390. National Bureau of Economic Research.

Mufson, S. 2012. The new boom: Shale gas fueling an American industrial revival. The Washington Post, 14 November.

National Park Service. 2009. Development of the Natural Gas Resources in the Marcellus Shale. Available at: http://www.nps.gov/frhi/parkmgmt/upload/GRD-M-Shale_12-11 2008_high_res.pdf.

New York Times. (2011). Wind money fuels spending and benefits in small schools. http://www.nytimes.com/2011/11/11/us/wind-money-fuels-spending-and-benefits-in-small-schools.html?_r=1&ref=windpower

Penn State University. 2009. Natural Gas Exploration: A Landowners Guide to Financial Management. Cooperative Extension. College of Agricultural Sciences. http://pubs.cas.psu.edu/FreePubs/pdfs/ui394.pdf

Plantinga, A.J., Lubowski, R.N., Stavins, R.N., 2002. "The effects of potential land development on agricultural land prices." *Journal of Urban Economics* 52, 561-581.

Resources for the Future. 2012. A Review of Shale Gas Regulations By State. Available at http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale_Maps.aspx

Scott, L.C. and Associates. 2009. The Economic Impact of the Haynesville Shale on the Lousiana Economy in 2008. Available at: http://dnr.louisiana.gov/assets/docs/mineral/haynesvilleshale/loren-scott-impact2008.pdf

Shaik, S., Helmers, G.A., Atwood, J.A., 2005. "The evolution of farm programs and their contribution to agricultural land values." *American Journal of Agricultural Economics* 87, 1190-1197.

Shapiro, M.D., Slemrod, J. 2003. "Consumer Response to Tax Rebates." *American Economic Review* 93(1): 381-396.

Shapiro, M.D., Slemrod, J. 2009. "Did the 2008 Tax Rebates Stimulate Spending?" *American Economic Review* 99(2): 374-379.

Sheffrin, H.M. and Thaler, R.H. 1988. "The Behavioral Life-Cycle Hypothesis." *Economic Inquiry* 26(4): 609–643.

Thaler, R.H. 1985. "Mental Accounting and Consumer Choice." *Marketing Science* 4(3): 199–214.

USDA-ERS, 2012a. U.S. and State Farm Income and Wealth Statistics. Available at: http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx#27428

USDA-ERS, 2012b. Farm Household Well-Being: Wealth, Farm Programs, and Health Insurance. Available at: http://www.ers.usda.gov/topics/farm-economy/farm-household-well-being/wealth,-farm-programs,-and-health-insurance.aspx#.Ua9W49LtXoI.

U.S. Department of Commerce, Bureau of the Census, 1993, "Who owns America's farmland?" Statistical Brief 93-10. Available at: http://grist.files.wordpress.com/2011/01/sb93_10.pdf

U.S. Department of Energy (USDOE), 2012, available at: http://www.windpoweringamerica.gov/wind_installed_capacity.asp

Weber, J. (2012). The effects of a natural gas boom on employment and income in Colorado, Texas, and Wyoming. *Energy Economics*, 34, 1580-1588.

Weersink, A., Clark, S., Turvey, C.G., Sarker, R., 1999. "The effect of agricultural policy on farmland values." *Land Economics* 75, 425-439.

Whitaker, James B. 2009. "The Varying Impacts of Agricultural Support Programs on U.S. Farm Household Consumption." *American Journal of Agricultural Economics*, 91(3), 569-80.

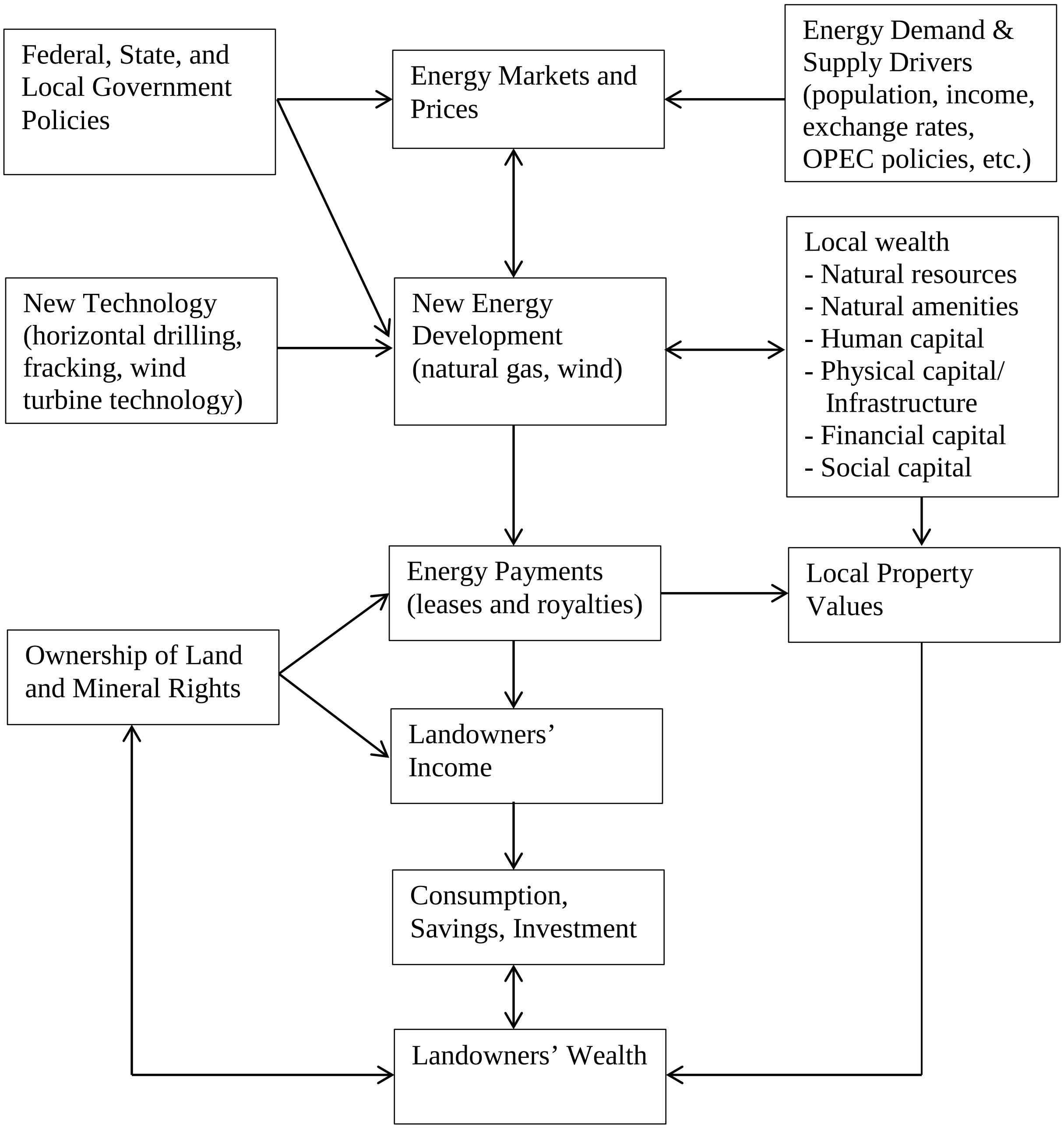
White, T.K. and R.A. Hoppe, 2012. "Changing Farm Structure and the Distribution of Farm Payments and Federal Crop Insurance." Economic information bulletin No. 91.

Williamson, J.M., Durst, R., and T. Farrigan, 2013, "The Potential Impact of Tax Reform on Farm Businesses and Rural Households," Economic Information Bulletin No. 107.

Windustry. 2005. "Wind Energy Easements and Leases: Best Practices and Policy Recommendations." Available at: http://www.windustry.org/sites/windustry.org/files/LandEBestPractices.pdf

Figures

Figure 1. Factors affecting rural energy development and its impacts on landowners



Tables

Table 1. Payments to farm businesses

Payment level	Percentage of farm businesses
1-1000	21.0
1001-5000	26.8
5001-25000	27.7
25001-50000	9.5
50001 or more	15.0
Median payment	7,000
Average payment	30,613

Source: 2011 Agricultural Resource Management Survey, Version 1.

Table 2. Energy and Government Payments by Region

Region	Median energy payment	Percentage of farms receiving payments	Percentage of total energy payments	Percentage of total government payments
Atlantic	$4,400	2.4	21	11.8
South	$5,000	1.1	2.5	13.9
Midwest	$1,079	2	3.8	30.8
Plains	$7,859	8	61.5	29.2
West	$13,000	2.5	11.2	14.3

Source: 2011 Agricultural Resource Management Survey, Version 1.

Table 3. Responses to Energy Payments: Consumption and Farm Investment

	Consumption		Farm Investment	
	(1)	(2)	(1)	(2)
	coef/se	coef/se	coef/se	coef/se
Energy payments	0.073	0.042**	0.096	0.103
	(0.046)	(0.018)	(0.137)	(0.126)
Farm income	0.009***	0.007***	0.124***	0.107***
	(0.003)	(0.002)	(0.032)	(0.030)
Off-farm income - earned	0.055***	0.059***	0.012	0.013
	(0.014)	(0.014)	(0.021)	(0.019)
Off-farm income - unearned	0.019	0.028*	-0.003	-0.012
	(0.013)	(0.017)	(0.022)	(0.013)
Farm net worth	0.001***	0.001***	0.019***	0.016***
	(0.000)	(0.000)	(-0.003)	(-0.002)
Nonfarm net worth	0.019***	0.019***	-0.005	0.001
	(0.002)	(0.002)	(0.013)	(0.005)
Age of primary operator	378	667***	-1492*	-1,194***
	(363)	(193)	(771)	(455)
Age squared	-5.690**	-7.838***	8.100	6.412*
	(2.748)	(1.598)	(6.198)	(3.713)
Intercept	27,736**	17,560***	61,622***	49,052***
	(11,717)	(5,816)	(23,701)	(13,766)
Observations	9,096	7,837	9,096	7,954
R-squared	0.077	0.103	0.133	0.168

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are calculated using the jackknife produced with 30 replicate weights. The second model for consumption excludes farm households that share with other households in the income from the farm and where the household rents its dwelling. The second model for farm investment excludes farm households that share with other households in the income from the farm.

Table 4. Energy Payments and Land Values

	With Wind coef/se	Excluding Wind coef/se
Energy payments	2.605*	2.492**
	(1.478)	(1.209)
Median county household income	8.558***	8.637***
	(2.837)	(2.913)
Driving distance to city of 250K or more	1,362***	1,384***
	(483)	(463)
Driving distance squared	-2.373***	-2.435***
	(0.618)	(0.634)
Acres Owned	521	525
	(327)	(356)
Direct government payments	35.2***	33.7***
	(7.5)	(7.3)
Intercept	217,765	166,371
	(357,805)	(345,123)
Controls for land resource region	yes	yes
Controls for land capability classes in county	yes	yes
Controls for farm production specialty	yes	yes
Controls for state	yes	yes
Number of observations	9,938	9,866
R squared	0.30	0.29

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors are calculated using the jackknife produced with 30 replicate weights.

Table 5. Energy Payments and Consumption and Wealth

	Calculation	Total effect ($Billions)
Consumption	(0.043 x 2.3) + (1-.20-.043) x 0.019 x 2.3) + (0.001 x 2.6 x 2.3)	0.14
Wealth	((1-.20-.042) x 2.3) +(2.6 x 2.3)	7.72

Appendix

Appendix Table A1: Descriptive statistics for farm households

Variable	Mean	S.E.	Median
Consumption expenditures	38,022	454	32,750
Energy payments	952	230	0
Farm income	20,751	1,128	-1,823
Earned nonfarm income	50,871	1,701	32,500
Unearned nonfarm income	21,316	819	12,500
Farm net worth	751,832	9,323	382,436
Nonfarm net worth	253,883	6,751	166,250
Operator age	59	0.32	59

Source: 2011 Agricultural Resource Management Survey, Version 1. The descriptive statistics are for the same sample used to estimate the second consumption model.

[1] Total U.S. primary energy production grew from 69.44 quadrillion Btu (qBtu) in 2005 to 78.15 qBtu in 2011, while natural gas production grew from 18.56 qBtu to 23.51 qBtu (accounting for 57 per cent of the growth in total production), biomass energy production grew from 3.10 qBtu to 4.51 qBtu (16 per cent of growth in total production), and wind energy production grew from 0.18 qBtu to 1.17 qBtu (11 per cent of growth in total production) (U.S. Energy Information Administration, October 2012).

[2] For more information on the ARMS is available at: http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx.

[3] If the intercept in (2) were omitted, the interpretation of the coefficients could be shown to be the same as if all continuous variables were put on per acre terms. Suppose an initial per acre specification: $\frac{V}{Acres} = \alpha + \beta\left(\frac{E}{Acres}\right) + \eta$. Multiplying by *acres* would give $V = \alpha Acres + \beta E + \eta Acres$. If the covariance between *Acres* and the error term is zero, we can re-write the equation as $V = \alpha Acres + \beta E + \varepsilon$. Relative to a per-acre specification, controlling for acres owned as an independent variable and having the total value of land as the dependent variable reduces statistical noise from measurement error in acres, thereby improving precision in estimates. However, error in measuring acres will bias its coefficient towards zero. With extreme measurement error the coefficient will be zero and is similar to simply omitting *Acres* from the model. Thus, as measurment error increases, so does the potential for omitted variable bias.