Energy Price Fluctuations and Small-Business Dynamics

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(Unfinished Draft)

Abstract

Change in business turnover is a potential but often overlooked channel through which energy price shocks are transmitted to the economy. By utilizing annual business turnover information and various energy prices for all U.S. states between 1979 and 2012, we confirm that changes in energy prices do have a sizable impact on small-business dynamics. We were also able to provide a richer characterization of this impact. Formal statistical tests are unable to reject the hypothesis of symmetric and linear responses to energy price movements for both entry and exit. In addition, small-business exits appear to react differently to local and national price changes, suggesting that firm relocation may play a key role here.

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1 Introduction

Energy prices rose considerably from the late 1990s until 2008, with the real cost per million btu more than doubling in the US. The onset of the global recession in 2008 brought the upward trend to an end but was marked by a spike in price volatility. As a result of the upward-trending and increasingly volatile energy prices, business decision-making has become more challenging. This is especially true for existing and potential small-business owners, as their sizes limit their ability to sign long-term contract or utilize hedging techniques in the financial market. In a 2012 survey by the Small Business & Entrepreneurship Council in the US, 72 percent of respondents said that"higher gas prices are impacting their business and 43 percent of respondents agreed that"their business will not survive if energy prices continue to remain high or increase further.

Although the impact of energy price shocks on existing US firms has been extensively studied, especially in the area of employment turnover and investments (Davis and Haltiwanger, 2001; Edelstein and Kilian, 2007; Lee and Ni, 2002), little attention has been paid to the impact on small business dynamics. Furthermore, the impact of oil shocks on various aspects of the economy, based on the price measures first constructed by Hamilton (2003) has been the focus of the literature, which largely ignores movements in other energy prices and possible price differences across US states. The objective of this paper is to fill that gap by documenting the impact of energy price movements across different states on the extensive margin of the small business sector.

We incorporated energy prices from the Energy Information Administration and annual business turnover data from the US Census Business Dynamic Statistics for all U.S. states between 1978 and 2012. Instead of employing the typical VAR (vector autoregression) methods used in the literature, we estimated a fixed-effect panel model. There were two primary reasons for this approach: First, the data set covers all U.S. states through the above period, which allowed us to explore both the cross-section and time-series features; second, there were only a few periods in our observation,[1] which made the VAR approach inappropriate. In addition, the implantation of the panel data model allowed us to correct for biases caused by fixed effects associated with unobserved state characteristics.

The main result of the paper is that we can confirm that energy price movements

[1] Although the period is long, the frequency is annual, which leaves us with only 34 periods. Most studies in the literature use either quarterly or monthly data, which provides more periods within a shorter time.

do have a sizable impact on entry and exit decisions, with price increases(decreases) lowering(raising) entries(exits) and raising(lowering) exits(entries). Formal statistical tests cannot reject the hypothesis that the responses of entry and exit to price movements are linear and symmetrical. In addition, we show that the responses of entry rates to national vs. local price changes are the same. On the other hand, exits have different responses to local and national price changes: A local price increase while the national price remains the same will lead to more exits, most likely through the relocation of firms. However, a national price increase will have little impact on exit rates. Our results are robust to the exclusion of the late 70s to early 80s(when prices were most volatile), as well as the exclusion of energy production states.

The impact of oil price uncertainty on macroeconomic activities has been extensively studied for the U.S. (Hamilton, 2003, 2011; Lippi and Nobili, 2009), Canada (Elder and Serletis, 2009; Rahman and Serletis, 2012), and the world economy (JO, 2014). Hamilton (2008) provided a comprehensive survey of this literature, and this was supplemented by Kilian (2008). In general, these studies concluded that there is a sizable impact from unanticipated changes in energy prices on U.S. consumer expenditures and firms investment expenditures, with many of them finding that there is an asymmetry in the responses to energy price increases and decreases. More related to this paper, Davis and Haltiwanger (2001) used plant-level data to study the effects of oil price shocks on job creation and destruction among the U.S. manufacturing sector. They concluded that oil shock accounted for 20-25 percent of the variability in employment growth in that sector. They also find that both job destruction and creation show short-run sensitivity to oil shocks for young, small plants. Lee and Ni (2002) find that the impact of oil prices shock on economic activities is not just through the direct input cost effects for industries such as refiners and chemicals, but also by delaying purchasing decisions of durable goods, such as automobiles. Edelstein and Kilian (2007) investigate the impact of energy prices on firms' investment expenditures in the U.S.. Despite the common belief that the response of fixed investment to energy price increases differs from its response to energy price decreases, they find that once investments in mining are excluded, and the effect of the 1986 Tax Reform Act is considered, the responses are quite symmetric. In addition, their decompositions show that energy price shocks only had a minor impact on nonresidential fixed investment other than investments in mining. Kilian and Vigfusson (2011)'s study based on a structural model concluded that responses of real GDP to upward and downward movements of energy prices are symmetrical. More recently Patra (2015) demonstrated in a dynamic stochastic macro model that firm entry can be an important channel for the transmission of energy price shocks; and also serve as an amplifying mechanism as well. The model could replicate many of the commencements between energy prices and consumptions, investments and real wages, which highlights the importance of business dynamics in the study of energy prices and macroeconomic performances.

Bartik (1989) studied the location of businesses which also concerns energy prices of different states. In that paper, the author analyzes how the characteristics of U.S. states affect small-business start-up by estimating a fixed-effect panel model with only a few periods. The author found that many local policies and characteristics do affect small business location decisions, though energy prices do not seem to matter.

Our study differs from the existing literature in a couple of ways: First, instead of focusing on just crude oil prices, we utilize the comprehensive total energy price series, which reflects the unitization of all different sources. Much of the work in the literature has focused on the price of crude oil. It is the common perception that the fluctuations in energy prices since the 1970s has been driven by disturbances in crude oil markets. However, the share of energy consumption based on petroleum products has drastically decreased over the last few decades, in particular for the commercial sector (see Figure 1). As argued by Kilian (2008) neither gasoline nor crude oil prices are representative of energy prices when studying firm behavior. Second, we focus on small businesses as their ability to sign long-term contract or utilize hedging techniques in the financial market is limited by their size, thus making them the most vulnerable to energy price shocks. Furthermore, we note that the costs and processes of changes in the intensive margin, either in capital or labor are usually cheaper and easier when compared to changes in the extensive margin through entry and exit. Third, we explore the differences in energy prices across U.S. states. These price differences may be due to variations in local energy policies, geographical location, and many other factors, but the general business environment is very similar across regions, thus the data set offers better comparability when compared to cross-country studies.

The rest of the paper is organized as follows. In section 2, we present a simple model of business dynamics. Section 3 summarizes the data on energy prices and small business entry/exit. Section 4 and 5 presents the empirical model and our results. Section 6 concludes the paper.

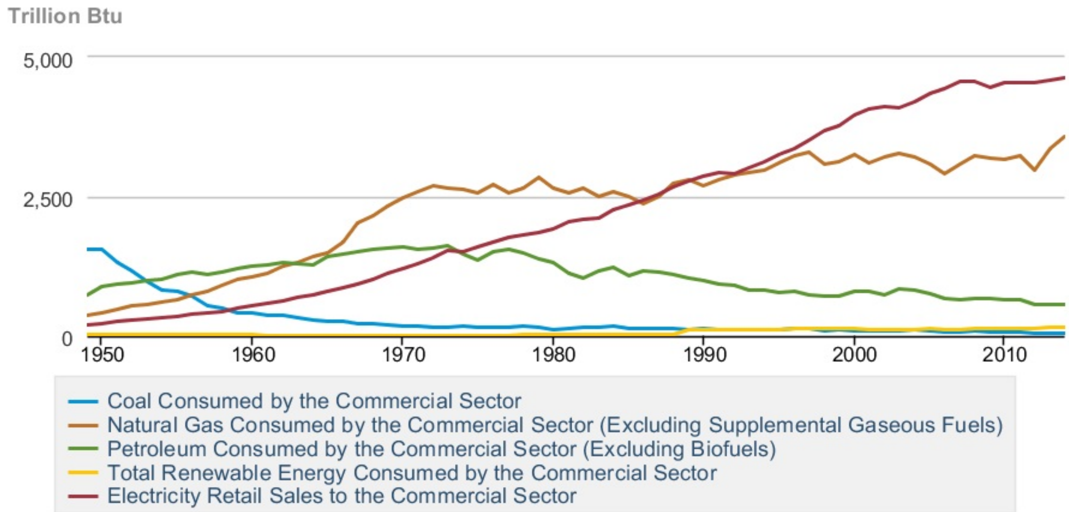

Figure 1: Commercial sector energy consumption. Source: U.S. Energy Information Administration

2 Model

We offer the simplest model of small-business dynamics to illustrate the impact of energy prices on profitability. Consider a risk-neutral agents who does not face any credit constraint with the option to operate a firm or work for a wage $\omega_{i,t}$. The period production function of the firm is defined as:

$$y(e,l) = z_{i,t} l^{\alpha} e^{1-\alpha}$$

where $z_{i,t}$ is an individual specific and time dependent productivity parameter, e denote the energy-related inputs and l denote all other inputs. Thus, the profit of a small business is:

$$v_{i,t} = z_{i,t} l^{\alpha} e^{1-\alpha} - P_e e - P_l l$$

where P_e is the relative price of energy prices and P_l is the price for other inputs. If the process of entering and exiting is costless, given an outside option $\omega_{i,t+1}$ the conditions for starting and quitting a business are easily defined:

$$\textbf{enter} \text{ if } E_t(v_{i,t+1}) > \omega_{i,t+1}$$

$$\textbf{exit} \text{ if } E_t(v_{i,t+1}) < \omega_{i,t+1}$$

Given the Cobb-Douglas setup, the cost function of the firm can be derived as:

$$C(y) = P_e^{1-\alpha} P_l^{\alpha} \frac{y}{z} [A^{-\alpha} + A^{1-\alpha}] \tag{1}$$

where $A = \frac{\alpha}{1-\alpha}$. The fact that (1) is a strictly increasing function of P_e implies that the profit strictly decreases in P_e for any given z and P_l. In addition, the impact of energy price on the profit depends on the energy intensity of the firm (industry) $(1 - \alpha)$, an intuitive result. This simple model highlights the direct relationship of energy prices and business dynamics: As long as agents believe that the energy prices are somewhat persistent, an increase in prices leads to increase in exits and a decrease in entries. More importantly, the responses are symmetrical.

3 Data description

3.1 Measurement and basic facts: small business turnover

To capture small-business turnover, we tabulate annual entry and exit time series for each state taken from the U.S. Census Business Dynamic Statistics between the years of 1978 and 2012. Given how the data are structured, we have two groups of small businesses: those with under 50 employees (small) and those with under 250 employees (small to medium). We establish turnover as rates out of the current-year total number of firms. We also use the entry and exit rates out of the total population as alternative measures. In order to study the short-run responses to transitory price shocks, we take the log of these data and then performed the Butterworth filter. The advantage of the Butterworth over the HP filter for the use in business cycle studies has been discussed extensively by Gomez (2001) and Pollock (2000).

Figure 2 provides a snapshot of the entry and exit rates of firms with less than 50 employees for all states. We first noticed that there is no strong indication of a trend for either set of rates. The rates of entry tend to hover around 9.5%, while the exit rates are generally lower at around 8.5%, which indicates that the number of firms has been increasing over time. In addition, the business turnover experiences are not uniform across states. There appears to be a significant deviation for any given year, and often the directions of changes from year to year are different across states. Lastly, the entry rates are a lot more volatile when compared to the exit rates.

We also provide the summary statistics for all entry and exit rates for the two different groups in Table 1. Similar observations are presented: First, average entry rates are higher than average exit rates; second, entry is more volatile than exit. In

Figure 2: Firm entry and exit rate for firms with less than 50 employees

addition, we also noticed the rates for the groups with less than 250 employees are lower. This is due to the fact larger firms tend to be more stable.

Table 1: Summary statistics for entry and exit rate

Variable	**Mean**	**Std. Dev.**
Firm entry rate, under 50	0.094	0.03
Firm exit rate, under 50	0.082	0.015
Firm entry rate, under 250	0.092	0.029
Firm exit rate, under 250	0.079	0.015

3.2 Energy prices

We include four different price series from the U.S. Energy Information Administration for each state: electricity, petroleum, natural gas and all sources. These price series were corrected for inflation using the annual CPI data provided by the BEA (Bureau of Economic Analysis).

Figure 3 presents the real (corrected for inflation) cost of energy from all sources, petroleum, natural gas, and electricity, respectively. The general observations are: first, real costs are increasing over time except for electricity; second, higher volatilities are presented in the early 1980s and late 2010s; third, energy prices and their movements are not uniform across states, especially for electricity.

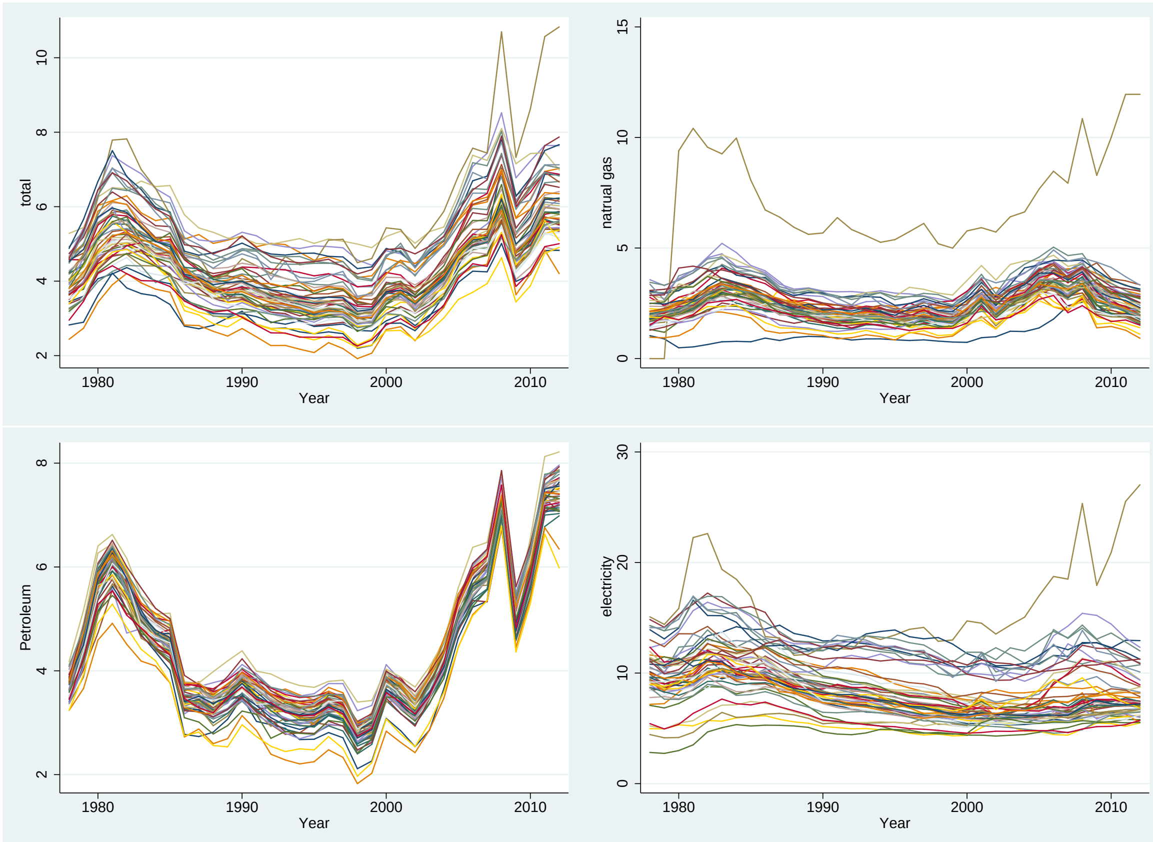

Figure 3: Real energy cost per million btu

To confirm that the price movements are not uniform across states for the period, we present the transitory price shocks as a percentage of the trend for each series in 4. Mainly driven by the large swing in oil prices, the price movements from all sources are more uniform in the 2000s. In contrast, the price movements were very different among states for the earlier periods. It appears that most of these differences in price movements are driven by prices of electricity and natural gas, which contribute to about 70% of the consumption by the commercial sectors.

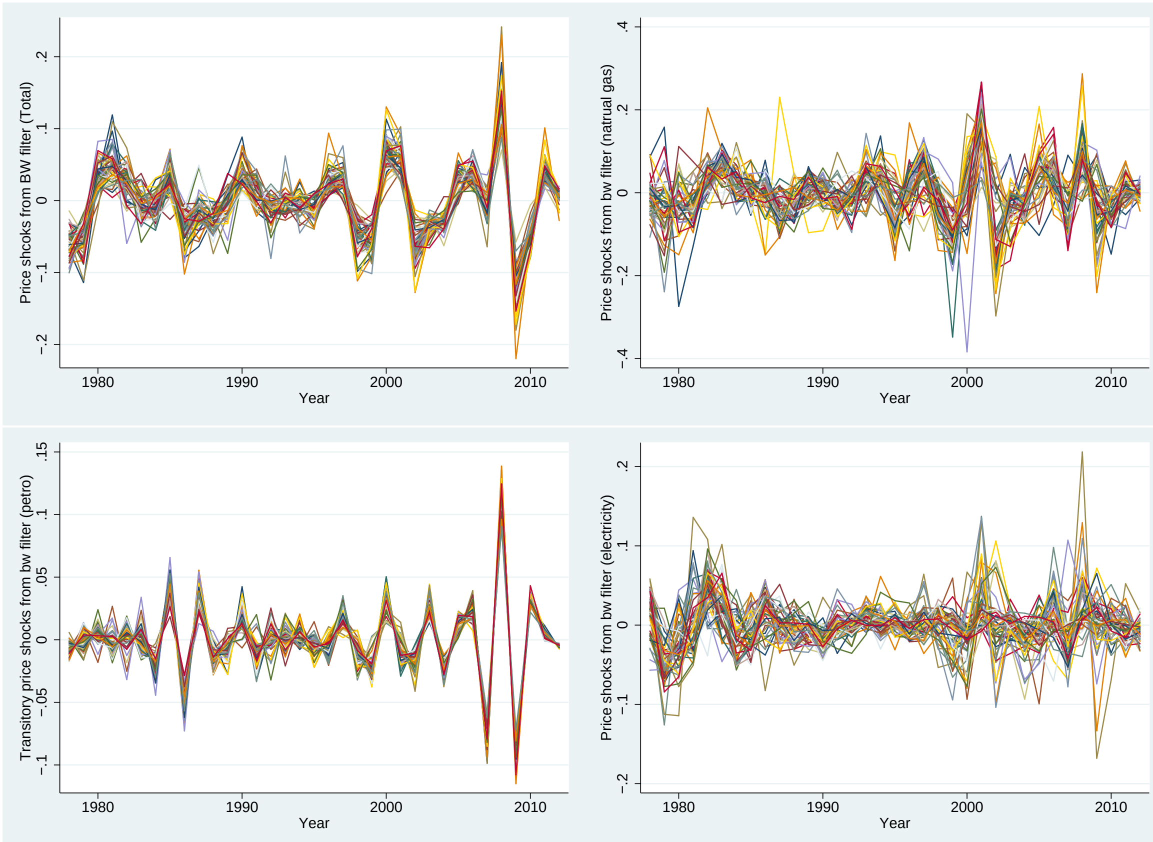

Figure 4: Transitory price shocks, BW filtered

3.3 Other variables

In order to isolate the effects of energy price changes, additional variables are needed to capture other factors impacts on entry and exit decisions, such as the macroeconomic conditions. Thus, we included the real GDP per capita at the state level, unemployment rate from the BEA as indicators for state economic conditions, as well as the yearly loan-over-deposit spread for US from the World Bank as a measurement of credit/monetary conditions.

4 Econometric model

After performing standard dick-fuller and Phillips-Perron tests, we confirm that entry and exit rates are stationary for this period. The only non-stationary variables are the energy prices. The model used to test the main hypotheses of this paper is a simple fixed effect panel model

$$R_{i,t} = \alpha + \sum_{t=1}^{T-1} \lambda_t T_t + \sum_{k=1}^{N} \eta_k d_k + \sum_{j=1}^{J} \beta_j X_{j,i,t-1} + \theta P_{i,t-1} + u_{i,t}$$

where $R_{i,t}$ is the entry or exit rate, X represents a series of variables intended to capture the business cycle, and $P_{i,t}$, represents a variable reflecting the real price of energy. Finally, d_i and T_t represent the state and time dummy variables, respectively. To avoid any potential for endogenous variable bias, all explanatory variables are lagged by one year.

In the analysis to follow the main explanatory variables used to control for the business cycle are the growth rates of real GDP and the change in unemployment rate. In addition to this, the lagged rate of entry or exit is also used in certain regressions. For example, because a large number of new businesses fail shortly after creation, the lagged rate of entry is found to be an important predictor of the exit rate Similarly, the lagged rate of exit is an important predictor of the rate of entry.

Due to the high likelihood of common correlated effects, we follow Pesaran (2006) and augment our model with the cross section average of each explanatory variable in each period (indicated by a bar over the variable). While the main practical purpose of this augmentation is to strengthen the robustness of the estimator, it also presents an opportunity to test an additional hypothesis of interest to this paper; the potential for differing impacts of local changes in energy prices versus those that are more national in nature. To test this, we employ a slightly modified specification:

$$R_{i,t} = \alpha + \sum_{t=1}^{T-1} \lambda_t T_t + \sum_{k=1}^{N} \eta_k d_k + \sum_{j=1}^{J} \beta_j X_{j,i,t-1} + \sum_{j=1}^{J} \phi \bar{X}_{j,t-1} + \theta P_{i,t-1} + \theta_1 \bar{P}_{t-1} + \sigma \bar{R}_t + u_{i,t}$$

In addition to testing the significance of individual parameters, the joint significance of the energy price variables ($\theta = \theta_1 = 0$) is also evaluated. Finally, it is also of interest whether the movement in local energy costs has a different impact than national trends ($\theta = \theta_1$).

Lastly, note that there is no generally agreed-upon specification of the energy price variable in the literature, leaving U.S. with little choice but to allow the data to select our specification. As such, we examine both the price and its growth rate. The results that follow reveal that the best specification varies based on the dependent variable being examined. The significance of individual coefficients is tested using t-statistics (standard errors in parentheses). To conserve space, the results for dummy variables and most cross-sectional means are not reported. The joint hypotheses are tested using F-tests (p-values in parentheses).

5 Empirical results

In all results, the estimated parameter estimates for the business cycle variables is consistent with standard intuition. Namely, higher GDP growth and lower unemployment rates lead to more entries and fewer exits, and vice versa. Moving to the energy related parameters, the results are generally supportive of the broader hypothesis that energy prices movements have a sizable impact on the entry and exit decisions of small to medium-size firms. The results for the entry rate are presented in Table 2

Table 2: Entry

	Under 50	Under 250
GDP Growth - lag 1	0.015*** (0.002)	0.016*** (0.002)
Unemployment - lag 1	-0.047*** (0.010)	-0.051*** (0.010)
Exit - lag 1	0.425*** (0.052)	0.397*** (0.046)
% Change in Price of Energy (Local)	-0.248* (0.145)	-0.263* (0.144)
% Change in Price of Energy (National)	-0.002 (0.094)	0.011 (0.092)
Constant	0.242 (0.723)	-0.192 (0.652)
Adjusted R2	0.655	0.664
$\theta = \theta_1 = 0$	18.11*** (0.000)	17.770*** (0.000)
$\theta = \theta_1$	31.48*** (0.000)	31.100*** (0.000)

The main effects of energy price changes on small-business entry are shown in columns 4 and 5 in Table 2. The negative coefficient on the local price change is expected and is statistically significant at the 10% level. Although the estimate on national price change is not significant, this does not mean it does not have any impact on entry. When the aggregate energy price moves, local prices change as well, and thus, the total effect is a combination of the two. The lagged exit rate is also a significant determination of entry, which is expected as the small business sector is very volatile, with many owners quitting and restarting soon afterward, and vice versa. In addition, there is little difference between the estimates of the under-50 and under-250 employees groups, which is due to the fact that the majority of the changes in the entry are among the group of smaller firms. This is because there are more small-sized than medium-sized firms in our sample, and entry/exit is easier for small firms as well.

Table 3: Exit

	Under 50	Under 250
GDP Growth - lag 1	-0.008*** (0.002)	-0.008*** (0.002)
Unemployment - lag 1	0.051*** (0.012)	0.052*** (0.012)
Exit - lag 1	0.184*** (0.069)	0.195*** (0.074)
% Change in Price of Energy (Local)	0.232* (0.134)	0.230* (0.133)
% Change in Price of Energy (National)	-0.257*** (0.044)	-0.267*** (0.044)
Constant	-0.166 (0.462)	-0.249 (0.469)
Adjusted R2	0.365	0.374
$\theta = \theta_1 = 0$	5.191*** (0.006)	5.660*** (0.003)
$\theta = \theta_1$	8.398*** (0.004)	9.298*** (0.002)

Table 3 presents effects of energy price changes on small-business exits. The estimates on local price change and lagged exit are expected and statistically significant. However, the sign on the estimate of the national price change is positive. Once again, we need to analyze the effects of national and local price movements together. Consider that there is an increase in the aggregate energy price level, such as an oil shock; then both national price and local price go up. With our estimates, these two effects cancel each other, leaving the exit rates roughly unchanged. On the other hand, if local price increases with no movement in the national price, then firms do exit. These results suggest that existing firms react less to aggregate price changes such as those caused by an oil shock, but do react to energy price differences across states by relocating their firms.

Significant efforts in the literature were put on investigating whether the response to energy price shocks is non-linear and asymmetrical (Kilian, 2008). We formally test the hypothesis that the responses of entry/exit rates to energy price changes are linear and symmetrical by utilizing several threshold models, and were not able to reject any of them. Results are shown in Table:

5.1 Robustness

Both entry/exit and energy price were quite volatile in the early years of the sample period (19781985), which raises some concerns that the results might be mainly driven by this period. Thus, we estimated both regressions excluding that period, and our findings were not significantly altered. We also tried estimating the models using entry and exit rates out of the population rather than existing firms, which confirmed our previous results. In addition, we divided states into two groups and found no significant differences between the net energy production and net energy consumption groups. Our intuition is that energy firms tend to operate on a much larger scale and thus, will be less likely to be represented in our sample.

6 Conclusion

This paper analyzed the dynamic effects of energy price changes on small-business turnover using state-level data. We found that entries and exits respond to energy price movements in the expected way and a linear and symmetrical fashion. Our study provides a rationale for incorporating entry and exit decisions into dynamic general equilibrium models when studying energy. In addition, the way exits react differently to national and local price movements has policy implications. In particular, energy policies should be coordinated among local governments because there are usually large direct and indirect costs associated with the business relocation process, such as temporary or even permanent unemployment spells.

References

Bartik, T. J. (1989). Small business start-ups in the united states: Estimates of the effects of characteristics of states. *Southern Economic Journal 55*(4), 1004–1018.

Davis, S. J. and J. Haltiwanger (2001). Sectoral job creation and destruction responses to oil price changes. *Journal of monetary economics 48*(3), 465–512.

Edelstein, P. and L. Kilian (2007). The response of business fixed investment to changes in energy prices: a test of some hypotheses about the transmission of energy price shocks. *The BE Journal of Macroeconomics 7*(1).

Elder, J. and A. Serletis (2009, November). Oil price uncertainty in Canada. *Energy Economics 31*(6), 852–856.

Gomez, V. (2001). The use of butterworth filters for trend and cycle estimation in economic time series. *Journal of Business & Economic Statistics 19*(3), 365–73.

Hamilton, J. D. (2003, April). What is an oil shock? *Journal of Econometrics 113*(2), 363–398.

Hamilton, J. D. (2008). oil and the macroeconomy. In S. N. Durlauf and L. E. Blume (Eds.), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan.

Hamilton, J. D. (2011, November). Nonlinearities And The Macroeconomic Effects Of Oil Prices. *Macroeconomic Dynamics 15*(S3), 364–378.

JO, S. (2014). The effects of oil price uncertainty on global real economic activity. *Journal of Money, Credit and Banking 46*(6), 1113–1135.

Kilian, L. (2008). The economic effects of energy price shocks. *Journal of Economic Literature 46*(4), 871–909.

Kilian, L. and R. J. Vigfusson (2011). Are the responses of the u.s. economy asymmetric in energy price increases and decreases? *Quantitative Economics 2*(3), 419–453.

Lee, K. and S. Ni (2002, May). On the dynamic effects of oil price shocks: a study using industry level data. *Journal of Monetary Economics 49*(4), 823–852.

Lippi, F. and A. Nobili (2009, March). Oil and the macroeconomy: a quantitative structural analysis. Temi di discussione (Economic working papers) 704, Bank of Italy, Economic Research and International Relations Area.

Patra, S. (2015). Energy in a model of Firm Entry. *Working Paper*.

Pesaran, M. H. (2006, July). Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure. *Econometrica 74*(4), 967–1012.

Pollock, D. S. G. (2000, December). Trend estimation and de-trending via rational square-wave filters. *Journal of Econometrics 99*(2), 317–334.

Rahman, S. and A. Serletis (2012). Oil price uncertainty and the Canadian economy: Evidence from a VARMA, GARCH-in-Mean, asymmetric BEKK model. *Energy Economics 34*(2), 603–610.