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Abstract

The aim of this study is to analyze the relationship between uncertainty and economic activity. For this purpose, we use a confidential firm level panel data set (Business Tendency Survey) from Turkey to form three uncertainty measures, namely total, idiosyncratic and aggregate uncertainty. In particular, we construct expectation errors of firms by comparing their survey responses about expectations and realizations on their production volume. Our results reveal countercyclical relationships between our uncertainty measures and economic activity. We further show that a one standard deviation increase in aggregate uncertainty is followed by a 0.5 percent decline in year-on-year change of industrial production on impact. The prolonged effect reaches more than 4.7 percent in a year for any of these three measures. In addition to the macroeconomic implications of uncertainty, we exploit the panel dimension of our data set to investigate the effects of firm specific uncertainty on that firm's investment decisions. Ordered probit estimation results show that if a firm makes more expectation errors -faces more uncertainty- it is more likely to defer investment plans even after controlling the aggregate uncertainty.

JEL classification: D8,C43,C82,E22,E32

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1. Introduction

Uncertainty has been critical in policy making and business. In *The Inflation Report* prepared quarterly by the Bank of England, the word "uncertainty" was used 30 times in November 2006 but used 74 times in November 2007 at the beginning of the current crisis. Moreover, uncertainty has been frequently used as one of the reasons of the changes in monetary policy. On January 22$^{\text{nd}}$ 2008 the Federal Reserve Board (Fed) lowered interest rates by 75 basis points and noted "The Committee took this action in view of a weakening of the economic outlook and increasing downside risks to growth" in the Federal Open Market Committee (FOMC) statement. On the business side, the importance of uncertainty has been widely accepted as well. For example, the McKinsey Quarterly 2009 global survey revealed that 47 percent of C-Level executives and senior managers of the 1653 respondents admitted to having feelings of general business uncertainty during an economic crisis.

The relation between uncertainty and economic activity has not been explored in detail until recently. Starting with Guiso and Parigi (1999), which shows that uncertainty weakens the response of investment to demand thus slowing down capital accumulation, researchers have directed their attention to the effects of uncertainty on real variables. For example, Bloom, Bond and Van Reenen (2007) analyzes the relationship between uncertainty and investment dynamics and empirically shows that firms facing higher uncertainty give a weaker response to demand shocks. Bloom (2009), on the other hand, formally argues in a partial equilibrium model that higher uncertainty can cause a recession as it will lead firms to use "wait and see" strategies, which will cause a slowdown in economic activity. As a proxy for uncertainty, he uses stock market volatility to show that the volatility of the stock market increases after major events such as September 11 and OPEC oil price shocks. In an accompanying paper, Bloom, Floetotto and Jaimovich (2009) show more evidence using data from establishments, firms, industries and macro economic variables that uncertainty is countercyclical. They then build on their theoretical general equilibrium model to study the effects of uncertainty on economic activity which confirm the earlier findings of Bloom (2009).[1]

In this paper, we use a confidential firm level data set from Turkey to form several measures of uncertainty. In particular, we construct expectation errors of firms by comparing their survey responses about expectations and realizations on their production volume. For example, if a firm expects an increase in its production for the next three months but does not report an increase (may report "*decrease*" or "*remain unchanged*") when asked again three months later, we consider that the firm made an expectation error. We assume that the probability of making an expectation error by a firm increases when the uncertainty faced by that firm increases. In Section 2 we theoretically motivate this assumption. We show that, our assumption about the relationship between uncertainty and expectation errors is easily satisfied in a dispersed information setup similar to the ones used in Morris and Shin (2002) and Lorenzoni (2009, 2010).

We first form firm specific errors as explained above and then introduce the measure "total uncertainty" as being the sum of squared firm specific errors (or equivalently, sum of firm specific uncertainties). The way we construct the uncertainty measure enables us to separate total uncertainty into two components. We name one of the components as "idiosyncratic uncertainty" and the other as "aggregate uncertainty". Idiosyncratic uncertainty is the variance of expectation errors made across firms. One problem with the former measure is that when all firms make the same expectation error, idiosyncratic uncertainty measure implies zero uncertainty. On the other hand, aggregate uncertainty is defined as the square of the average expectation error made across firms. Consequently, the aggregate uncertainty measure signals high uncertainty if high number of firms make similar expectation errors.

Earlier measures of uncertainty which use either establishments, firms, industries or macro economic variables can be criticized on the front that it is hard to know how much of the movements in those variables were expected and known. At the extreme case, it is possible that each firm may exactly know what is going to happen even though

[1]See also Fatás (2002); Ogawa and Suzuki (2002); Bloom (2007); Fernández-Villaverde and Rubio-Ramírez (2010); Arellano, Bai and Kehoe (2010); Fernández-Villaverde et al. (2011).

the uncertainty measure obtained from them respectively gives significant uncertainty. Some studies, such as Bloom (2009) and Leahy and Whited (1996), use stock market volatility as a measure of uncertainty. This measure is criticized by Guiso and Parigi (1999) as the stock market can sometimes be affected more by irrational exuberance than economic fundamentals. Another commonly used uncertainty measure is the variance of forecasters' expectations. This measure suffers from the critique that what really matters is not the forecasters' expectations but the producers' expectations. Moreover, the number of forecasters in expectation survey is small in general. This paper develops a new uncertainty measure which is free from the earlier critics of the other uncertainty measures.

To study the relationship between uncertainty and economic activity, we use the uncertainty measure that we form and Industrial Production Index (IPI) of Turkey published by Turkish Statistical Institute (TURKSTAT). The cross correlations show that there is a strong negative correlation and uncertainty leads economic activity by five months similar to the VAR findings of Bloom (2009). Apart from high negative correlation, a unidirectional causal relationship from uncertainty to economic activity has been explored from Granger causality test results. This unidirectional causality along with rejected endogeneity tests supported the exogeneity of uncertainty. Next, we show that a one standard deviation increase in aggregate uncertainty causes a 0.5 percent decrease in IPI on impact. If we take into account the prolonged effects, the decrease in IPI reaches more than 7 percent in a year. We further show that the effects of aggregate uncertainty are stronger than those of other two measures.

In a contemporary paper, one of the methods that Bachmann, Elstner and Sims (2010) use to measure uncertainty is similar to our method. Although they confirm the strong negative relationship between uncertainty and economic activity, they conclude that they do not see the "wait-and-see" effect after their VAR analysis. They argue that uncertainty does not cause recession, but recessions cause uncertainty. Our paper uses a different uncertainty measure than the one used in Bachmann, Elstner and Sims

(2010). In particular, when every firm in the survey make the same error their uncertainty measure implies zero uncertainty. Our measure treats these expectation errors as uncertainty. In fact, we are able to separate total uncertainty into idiosyncratic and aggregate uncertainty. Idiosyncratic uncertainty measure used in this paper is the same as the measure that Bachmann, Elstner and Sims (2010) use. We show that aggregate uncertainty measure is more effective in all the economic activities that we analyze.

Finally, we utilize the panel dimension of our dataset to investigate the effects of aggregate and firm specific uncertainty on investment decisions. Our results show that both aggregate and firm specific uncertainties have negative effects on investment plans. This is inline with Bloom (2009) and Bloom, Floetotto and Jaimovich (2009). According to our findings, under positive demand and supply conditions, an increase in the aggregate uncertainty decreases the probability of making new investment decision from 34 percent to 10 percent and increases the probability of discarding new investment decision from 16 to 44 percent while an increase in the firm specific uncertainty decreases the probability of making new investment decision from 34 percent to 22 percent and increases the probability of discarding new investment decision from 16 percent to 25 percent. We find similar results under negative demand and supply conditions.

The remainder of this paper is organized as follows. In section 2, we discuss a theoretical model where as the uncertainty in an economy increases expectation errors also increase. The next section introduces data and methodology used in the paper. Section 4 reports the results of the econometric tests and analysis. Section 5 investigates effects of uncertainty on firm investment while section 6 concludes the paper. Furthermore in an appendix, we compare the performances of other uncertainty measures proposed in the literature.

2. Model

In this section, we introduce our model in which we will show that if uncertainty increases expectation errors also increase. Moreover, we show that the other direction of the relationship also holds. Particularly, we prove that movements in square of expectation errors can only be correlated with changes in uncertainty. For this purpose, we use a dispersed information setup similar to the ones used in Morris and Shin (2002) and Lorenzoni (2009, 2010).

The model economy is populated by a continuum of firms indexed by i, whose production growth can be written as

$$y_{i,t} - y_{i,t-1} = \theta_t + \zeta_{i,t} \tag{1}$$

where $y_{i,t}$ is the logarithm of production of firm i at time t. Production growth of a firm has two components; the aggregate component θ_t and the idiosyncratic component $\zeta_{i,t}$. Both processes are independent and identically distributed normal with mean zero and respective variances σ_θ^2 and σ_ζ^2. Moreover, these processes are independent from each other, i.e. neither have any information on guessing the other. More importantly, firms do not have perfect information of θ_t but they receive two noisy signals about the aggregate component.[2] One of the noisy signals is private information with the specification

$$x_{i,t} = \theta_t + \epsilon_{i,t} \tag{2}$$

where $\epsilon_{i,t}$ is independent and identically distributed normal with mean zero and variance σ_ϵ^2. The other signal, on the other hand, can be observed publicly and has the form

$$s_t = \theta_t + e_t \tag{3}$$

where e_t is independent and identically distributed (i.i.d.) normal with mean zero and variance σ_e^2. Again, processes θ_t, $\zeta_{i,t}$, $\epsilon_{i,t}$ and e_t are independent both across agents and across time. The two noisy signals modeled are the sources of dispersed informa-

[2]The idiosyncratic process $\zeta_{i,t}$ may or may not be known but we only need to analyze the aggregate component, which is exposed to dispersed information.

tion in the model. The public noise shock e_t causes all the firms to underestimate or overestimate the macro production innovation. The idiosyncratic noise shock $\epsilon_{i,t}$, on the other hand, causes dispersed information about the current state of the micro and macro productivities given s_t.

Given the signals in the economy, firms form their expectations about the aggregate component of their production growth. Expected aggregate production growth is

$$E[\theta_t|x_{i,t}, s_t] = \frac{\alpha s_t + \beta x_{i,t}}{\alpha + \beta} \tag{4}$$

where $\alpha = 1/\sigma_e^2$ and $\beta = 1/\sigma_\epsilon^2$ are precisions of the public and private information, respectively. Equation 4 suggests that firms give more weight to the information with higher precision. Letting $\kappa_{i,t} = \frac{\alpha e_t + \beta \epsilon_{i,t}}{\alpha+\beta}$, the term on the right hand side can be rewritten as

$$\frac{\alpha s_t + \beta x_{i,t}}{\alpha + \beta} = \theta_t + \kappa_{i,t} \tag{5}$$

where using normality and i.i.d. property, $\kappa_{i,t} \sim N(0, \frac{1}{\alpha+\beta})$.

To maintain compatibility with our dataset, in which firms give qualitative responses about expectations and past realizations of their production volume, our model assumes that each firm reports whether they expect θ_t to be larger than some upper bound $\overline{\theta}$, smaller than some lower bound $\underline{\theta}$ or between $\overline{\theta}$ and $\underline{\theta}$.[3] Similarly, we assume that each firm reports one period later whether they observed θ_t larger than $\overline{\theta}$, smaller than $\underline{\theta}$ or between $\overline{\theta}$ and $\underline{\theta}$. Specifically, a firm reports $a(\theta_t)$ tomorrow and $a(E[\theta_t|x_{i,t}, s_t])$ today in the following sense:

[3] Bounds can be different for each firm.

$$a(\theta_t) = \begin{cases} 1, & \theta_t > \overline{\theta} \\ 0, & \underline{\theta} < \theta_t < \overline{\theta} \\ -1, & \theta_t < \underline{\theta} \end{cases} \tag{6}$$

$$a(E[\theta_t|x_{i,t}, s_t]) = \begin{cases} 1, & E[\theta_t|x_{i,t}, s_t] > \overline{\theta} \\ 0, & \underline{\theta} < E[\theta_t|x_{i,t}, s_t] < \overline{\theta} \\ -1, & E[\theta_t|x_{i,t}, s_t] < \underline{\theta} \end{cases} \tag{7}$$

If a firm's measured expectation $a(E[\theta_t|x_{i,t}, s_t])$ does not fit to the measured realization $a(\theta_t)$, we name this as an expectation error. More rigorously, U denotes the square of ex-post expectation error made by a firm which can be written as:

$$U(\theta_t) = [a(\theta_t) - a(E[\theta_t|x_{i,t}, s_t])]^2. \tag{8}$$

We will now show that as uncertainty in the economy rises, the probability of firms making expectation errors also increase for any realization of θ_t.

Lemma 1. *$\frac{\partial P(U(\theta_t)>0)}{\partial \sigma_e} > 0$ and $\frac{\partial P(U(\theta_t)>0)}{\partial \sigma_\epsilon} > 0$ for any θ_t unambiguously.*

Proof. There are only three cases where firms make no expectation error. Particularly, the following events will lead to $U = 0$:

i) $E[\theta_t|x_{i,t}, s_t] < \underline{\theta}$ given $\theta_t < \underline{\theta}$,

ii) $\underline{\theta} < E[\theta_t|x_{i,t}, s_t] < \overline{\theta}$ given $\underline{\theta} < \theta_t < \overline{\theta}$,

iii) $E[\theta_t|x_{i,t}, s_t] > \overline{\theta}$ given $\theta_t > \overline{\theta}$.

What we essentially show in this proof is that the probabilities of these events monotonically shrink as σ_e or σ_ϵ rise. Equivalently, it is enough to show that changes in α or β lead to changes in these probabilities in the same direction. To achieve this, we first define

$$Z_{i,t} = \kappa_{i,t}\sqrt{\alpha + \beta} \tag{9}$$

where using normality and i.i.d. property of $\kappa_{i,t}$, $Z_{i,t}$ is distributed i.i.d. as standard normal. Now, considering our first case,

$$\begin{aligned} P(E[\theta_t|x_{i,t},s_t] < \underline{\theta}) &= P(\theta_t + \kappa_{i,t} < \underline{\theta}) = P(\kappa_{i,t} < \underline{\theta} - \theta_t) \\ &= P(Z_{i,t} < \sqrt{\alpha+\beta}(\underline{\theta} - \theta_t)) \\ &= \Phi(\sqrt{\alpha+\beta}(\underline{\theta} - \theta_t)) \end{aligned} \tag{10}$$

where $\Phi(.)$ is the standard normal cumulative distribution function. Note that, since $\theta_t < \underline{\theta}$ in the first case, the term inside the operator $\Phi(.)$ is positive and is increasing in α or β. Therefore, any decrease in precision (or equivalently, an increase in uncertainty) leads to a decrease in the success probability. Proceeding to the second case,

$$\begin{aligned} P(\underline{\theta} < E[\theta_t|x_{i,t},s_t] < \overline{\theta}) &= P(\underline{\theta} < \theta_t + \kappa_{i,t} < \overline{\theta}) = P(\underline{\theta} - \theta_t < \kappa_{i,t} < \overline{\theta} - \theta_t) \\ &= P(\sqrt{\alpha+\beta}(\underline{\theta} - \theta_t) < Z_{i,t} < \sqrt{\alpha+\beta}(\overline{\theta} - \theta_t)) \\ &= \Phi(\sqrt{\alpha+\beta}(\overline{\theta} - \theta_t)) - \Phi(\sqrt{\alpha+\beta}(\underline{\theta} - \theta_t)). \end{aligned} \tag{11}$$

Now, there are two terms on the right hand side. Using $\underline{\theta} < \theta_t < \overline{\theta}$, one can see that the first term has a positive operand and therefore is increasing in precision terms which in turn leads to an increase in the first probability function. The second term, on the other hand has a negative operand and is decreasing in precision terms. This leads to a decrease in the second probability function and hence the sum of the two probabilities monotonically increase in α or β. This completes the proof.[4] ■

Finally, we consider the other direction of the relationship between uncertainty and expectation errors. In particular, an increase in square of expectation errors may stem from two possible causes in our model, an increase in uncertainty and a level shock in θ_t. However, we show that the latter is uncorrelated with squared expectation errors and thus movements in square of expectation errors can only be correlated with changes in uncertainty.

Lemma 2. *Assuming $\overline{\theta} - E[\theta_t] = E[\theta_t] - \underline{\theta}$, θ_t and $U(\theta_t)$ are uncorrelated.*

[4] Note that the third case is analogous to the first one.

Proof. The covariance between θ_t and $U(\theta_t)$ can be written as

$$Cov(\theta_t, U(\theta_t)) = E[\theta_t U(\theta_t)] - E[\theta_t]E[U(\theta_t)]. \tag{12}$$

Since $E[\theta_t] = 0$,[5] (12) simplifies to

$$Cov(\theta_t, U(\theta_t)) = E[\theta_t U(\theta_t)]. \tag{13}$$

Now, when we write possible values of $U(\theta_t)$,

$$U(\theta_t) = \begin{cases} 0, & \begin{cases} \theta_t < \underline{\theta} \text{ and } \kappa_{i,t} < \underline{\theta} - \theta_t \\ \underline{\theta} < \theta_t < \overline{\theta} \text{ and } \underline{\theta} - \theta_t < \kappa_{i,t} < \overline{\theta} - \theta_t \\ \theta_t > \overline{\theta} \text{ and } \kappa_{i,t} > \overline{\theta} - \theta_t \end{cases} \\ 1, & \begin{cases} \theta_t < \underline{\theta} \text{ and } \underline{\theta} - \theta_t < \kappa_{i,t} < \overline{\theta} - \theta_t \\ \underline{\theta} < \theta_t < \overline{\theta} \text{ and } \kappa_{i,t} < \underline{\theta} - \theta_t \\ \underline{\theta} < \theta_t < \overline{\theta} \text{ and } \kappa_{i,t} > \overline{\theta} - \theta_t \\ \theta_t > \overline{\theta} \text{ and } \underline{\theta} - \theta_t < \kappa_{i,t} < \overline{\theta} - \theta_t \end{cases} \\ 4, & \begin{cases} \theta_t < \underline{\theta} \text{ and } \kappa_{i,t} > \overline{\theta} - \theta_t \\ \theta_t > \overline{\theta} \text{ and } \kappa_{i,t} < \underline{\theta} - \theta_t \end{cases} \end{cases} \tag{14}$$

one can easily see that if bounds $\underline{\theta}$ and $\overline{\theta}$ are equidistant from the mean of θ_t, then $U(\phi) = U(-\phi)$ for any given $\phi \in \mathbb{R}$, i.e. $U(\theta_t)$ is symmetric with respect to θ_t. Therefore, $E[\theta_t U(\theta_t)] = 0$. ■

Lemma 2 tells us that unexpected movements in production growth (θ_t) causes expectation errors but those movements θ_t does not have any correlation with the expectation errors. This is because errors are symmetric around expected θ_t. If we observe large expectation errors for some θ, we will observe large expectation errors for $-\theta$ as well. To illustrate this better, Figures I depicts simulation results analyzing how average squared expectation errors change for fixed level of uncertainty.[6] As it can be seen from the figure, errors are made most frequently when shocks are near the decision bounds and almost zero errors are made near the tails. This is intuitive, firms don't make expectation errors

[5] The mean zero assumption is not crucial for the results. The only assumption needed is that bounds are equidistant from the mean.

[6] We use $\underline{\theta} = -1$ and $\overline{\theta} = 1$. Total number of random draws is 10,000.

when big shocks hit the economy because θ_t dominates the signals. According to the simulation results, the correlation between the level of shocks and squared expectation errors is almost zero. On the other hand, Figure II, which illustrates the relationship between uncertainty and squared expectation errors for fixed level of shocks, clearly shows that the main source of expectation errors is the uncertainty in the economy. A correlation of 0.924 is estimated in the simulation results.

Empirically, arguments above would imply that if the main source of expectation errors was the unexpected movements in the production growth θ_t, we would not see any correlation between expectation errors and economic activity. We would see small errors during extreme boom-bust periods and large errors during moderate recessions and moderate booms. In the next sections, we show that this view is not supported in Turkish data. In particular, we show that expectation errors are large before recessions (even larger before severe recessions) but it is not the case for booms. Hence an observed hike in squared expectation errors should be attained to increased uncertainty in the economy.

3. Data and Methodology

Business Tendency Survey (BTS) is a monthly survey conducted by the Central Bank of the Republic of Turkey (CBRT) since December 1987. It is aimed to produce indicators that will reflect the short-term tendencies in the manufacturing industry. The survey compiles the assessments of the senior managers on the recent past, current situation and their expectations regarding the future course of business environment. The scope of the survey involves many variables including production, sale orders, employment, inventories, prices, unit costs, producer prices inflation, interest rate on credits and general course of the business conditions.

A major structural break occurred in this survey at the end of 2006. Particularly, according to the "Joint Harmonized EU Programme of Business and Consumer Surveys", the harmonization of the BTS with the international standards and the improvement of the scope of the survey units were held and completed by the end of 2006. Before 2006, the survey units were industrial firms listed in the "Turkey's Top 500 Industrial Enterprises Survey" and "Turkey's Second 500 Industrial Enterprises Survey", published by the Istanbul Chamber of Industry. After the harmonization, the survey units come from the Monthly Industrial Production Survey that generate 90 percent of the total production value of the private sector units with annual average number of 20 or more employees at four-digit sectors of NACE Rev. 1.1.[7] With this harmonization study, a significant jump in the respondent size is observed. Specifically, an average of four times bigger set of firm managers participated in the survey after the harmonization period.[8] Descriptive statistics for the total respondent sizes of the two periods are given in columns 2 and 3 of Table I.

In this paper, we use expectation errors of firms on production volume to construct our uncertainty measures. Accordingly, answers to questions listed in Table VIII are used. Question 5 asks next three-month expectations regarding firms' production while question 1 asks about their realizations in the past three-month. Therefore, answers to expectation questions at time t and realization questions at time $t+3$ will cover the same period. This property allows us to analyze expectation errors as explained below.

In order to analyze the expectation errors, we first gathered the paired samples. In particular, firms with a valid answer at time t *and* $t+3$ formed our paired samples. Descriptive statistics of these paired samples through time are presented in columns 4 to 7 of Table I.[9] Survey responses of the firms in these paired samples are used to derive forecast errors. Specifically, if the answer to the expectation question is different than the answer to the relevant realization question, then this is called as an expectation error and

[7] Our data set does not allow us to control sectoral heterogeneities at the four-digit level of NACE 1.1. However, our results are robust when we control them at the two-digit level.

[8] More details about the survey can be found on CBRT website.

[9] One can observe the size differences of the paired samples for the two periods and these differences might cause a break in the time series analyzed. In order to investigate this possibility, we first applied the analysis for the original firms only (firms which participated in the pre-harmonization period), and then compared results with the one when we used all possible paired samples. Although the two samples consist of firms selected with different criteria, results of the paper, fortunately, are robust to this structural break.

will be identified as an unexpected shock to the relevant variables. For example, a firm which expects an "*increase*" in production (question 5) in January 2010 *and* responds to the realization (question 1) as "*decreased*" in the April 2010 survey, then we can say that this firm made an expectation error at January 2010.

Uncertainty and its relation with economic activity are analyzed empirically in this paper. Many measures have been used to represent economic activity in the literature but only a few measures have been developed for uncertainty. Our uncertainty measure is based on survey results and is an extension to the one used in Bachmann, Elstner and Sims (2010). They used root mean squared error (RMSE) measure on the survey expectation errors. Three possible answers[10] to each couple of questions construct a weight matrix for expectation errors as presented in Table III. As an example, if a firm manager expects an "*decrease*" and reports a "*increased*" ("*remained unchanged*"), then that firm's uncertainty will be measured as 1 (1/2). The reason there are different figures for different answers is that as the realization departs further from the expectation, the uncertainty measure should reflect this accordingly.

Once they obtained expectation errors, they introduce an uncertainty measure as the following:

$$Uncertainty_t^{Idiosyncratic} = \sum_{i=1}^{N} (W_{i,t} - \overline{W}_t)^2 / N, \tag{15}$$

where

$$\overline{W}_t = \sum_{i=1}^{N} W_{i,t} / N \tag{16}$$

and $W_{i,t}$ is the weight of expectation error of firm i at time t as introduced in Table III.[11] We name this measure as "*idiosyncratic uncertainty measure*" because it measures how individual firms depart from the overall mean on expectation errors. However, we think that this measure is inappropriate in measuring uncertainty. For example, if all the firms expect "*decrease*"s in their production over the next three months at time t

[10]We omitted "No Answer" responses for convenience. As a robustness check, those responses show no relation with economic activity.

[11]We use $W_{i,t}^2$ as the firm specific uncertainty measure in Section 5.

and observe a positive shock and report "*increase*"s over the past three months at time $t+3$, then the idiosyncratic uncertainty will take a value of zero. From this perspective, we study two more uncertainty measures, namely total and macro uncertainty measures, as introduced below.

$$Uncertainty_t^{Aggregate} = \overline{W}_t^2, \tag{17}$$

$$Uncertainty_t^{Total} = \sum_{i=1}^{N} (W_{i,t})^2 / N. \tag{18}$$

Using (15), (17) and (18), one can have the identity:

$$Uncertainty_t^{Total} = Uncertainty_t^{Idiosyncratic} + Uncertainty_t^{Aggregate}. \tag{19}$$

The *aggregate uncertainty measure*, $Uncertainty_t^{Aggregate}$, is the square of average expectation errors. Considering the example above, aggregate uncertainty measure will take a value of one, signaling a high uncertainty. At the other extreme, if the same proportion of firms make positive and negative expectation errors, and hence canceling each others' errors, this would mean an environment where firms face only idiosyncratic shocks. In this situation, the aggregate uncertainty will take a value of zero showing no aggregate shocks to economy.

The *total uncertainty measure*, $Uncertainty_t^{Total}$, captures all expectation errors. This includes both idiosyncratic and aggregate shocks that firms face. This identity is written in equation (19). In the next section, we analyze the relationships between each of these uncertainty measures and economic activity.

4. Results

4.1. Cross Correlations and Comovement

We depict our uncertainty measures with year-on-year changes in IPI[12] in Figure III as a measure of economic activity. As apparent from this figure, idiosyncratic uncertainty follows a more stable path and it cannot capture economic downturns. Aggregate uncertainty, on the other hand, seems to be a good leading indicator for the economic activity. One can observe that major spikes in aggregate uncertainty measure are followed by troughs in the economic activity.

As a next step, we report the cross correlations of our uncertainty measures with several macroeconomic variables, namely the IPI, investment, firms' investment and employment expectations, in Table IV. There are two important results that this analysis reveals. First, for each variable, there are strong negative correlations with our uncertainty measures (bold figures indicate the strongest absolute correlation among the lags). Moreover, one can see that uncertainty has leading property with a two to five months lags. Second, the results regarding the aggregate uncertainty measure are much stronger than the others, especially the idiosyncratic uncertainty, the one used by Bachmann, Elstner and Sims (2010).

First three rows of Table IV show the relationship between IPI and the three uncertainty measures. Aggregate uncertainty leads IPI with five months lag and has a correlation of -0.51, which means higher uncertainty today signals a decrease in production in five months. Idiosyncratic uncertainty, on the other hand, leads IPI with two months lag and has a lower absolute correlation with IPI, only -0.29.

We use two different variables related to investment to analyze the relationship between uncertainty. Second three rows of Table IV present the cross correlations of uncertainty measures with the first investment variable, gross fixed capital formation component of GDP with constant prices. Since GDP data is quarterly, we employ quarterly

[12]IPI is adjusted for calendar day effects. Atabek et al. (2009) provides evidence on the importance of calendar day effects on Turkish industrial production series.

averages of our uncertainty measures. According to the results, the relationship looks similar as in the case of production. The main difference is the change in the lag structure. Particularly, aggregate uncertainty leads investment with a three quarters lag (-0.54) while idiosyncratic uncertainty leads with a quarter lag (-0.37). Third three rows document the cross correlations of uncertainty measures with the second investment variable, investment expectations. Specifically, we use the expectations of own investment that we obtained from BTS balance results. The correlations are similar to the earlier ones of production and investment.

The last cross correlation analysis that we perform is between BTS firms' employment expectations and uncertainty. Results in the bottom three rows of Table IV further emphasize the relative importance of the aggregate uncertainty measure. In particular, idiosyncratic uncertainty shows no significant relationship between employment expectations and reduces the relationship of total uncertainty measure due to aggregation. Aggregate uncertainty, on the other hand, has a strong negative and leading relationship with employment expectations.

Figure V depicts aggregate uncertainty measure with investment (year-on-year change), investment expectations and employment expectations, respectively. All three subfigures show aforementioned evidence on leading and negative relationship between aggregate uncertainty measure and economic activity measures.

4.2. Granger Causality Tests

Granger causality test enables to make claims beyond correlation and to test for causation. The basic definition of the concept is quite simple and intuitive. Suppose that we have two variables, (X_t, Y_t). We first attempt to forecast X_{t+1} using past terms of X_t only and then try to forecast X_{t+1} using past terms of X_t and Y_t. If the inclusion of Y_t improves the forecasting performance, implying Y_t contain significant information helping in forecasting X_{t+1}, then it is said that Y_t would "Granger cause" X_t. Mathematically, to investigate whether or not X causes Y, the following equations are estimated:

$$
\begin{aligned}
Y_t &= \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} \beta_i X_{t-i} + \epsilon_t \\
X_t &= \sum_{i=1}^{p} \rho_i Y_{t-i} + \sum_{i=1}^{q} \gamma_i X_{t-i} + \vartheta_t
\end{aligned}
\tag{20}
$$

where p and q are the maximum numbers of lagged variables included in the model, $(\alpha_i, \beta_i, \rho_i, \gamma_i)$ are the coefficients and $(\epsilon_t, \vartheta_t)$ are residuals for each equation. X_t is said to Granger cause Y_t if the coefficients β_is are jointly significantly different from zero. This can be tested by performing an F-test of the null hypothesis $H_0 : \beta_1 = \beta_2 = ... = \beta_q = 0$ given the assumption of stationarity. Note that testing "Granger causality" within the above formulation requires two important assumptions about the data: (*i*) that it is covariance stationary (i.e., the mean and variance of each time series do not change over time), and (*ii*) that it is a well-defined model (lag selection is made appropriately).

In our framework, causal relationships between different uncertainty measures (aggregate, idiosyncratic and total uncertainty) and economic variables (industrial production index, investment, expectations of investment and employment) are investigated. Test results are given in Table V. The top panel of the table reports the causality test results for the industrial production index and our uncertainty measures. Results reveal that unidirectional causality from uncertainty to economic activity exists for all uncertainty measures. The second and third panel of the table shows the results for the investment and employment expectations. We obtain different results for different uncertainty measures. The idiosyncratic uncertainty measure is independent from investment and employment expectations since the causal relationship is rejected for both directions. Total and aggregate uncertainty measures, on the other hand, have the unidirectional causality from uncertainty to the economic variables.

4.3. Regression Results

After finding the unidirectional causality running from uncertainty to economic activity, we estimate the following specification to estimate the effect of uncertainty on economic activity:

$$y_t = \alpha + \sum_{i=1}^{5} \rho_i y_{t-i} + \beta X_{t-j} + \theta \epsilon_{t-12} + \epsilon_t, \tag{21}$$

where y_t is year-on-year change of IPI after calendar day adjustment. The error term, ϵ_t, is found to have a heteroskedastic variance and following Bollerslev (1986), a GARCH(1,2) model is estimated for the conditional variance:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2 \sigma_{t-2}^2. \tag{22}$$

To analyze the effects of uncertainty on industrial production, we feed uncertainty measures to the regression equation one by one. X_{t-j} is the uncertainty measure where j is the appropriate lag. Table VI shows the estimation results for different specifications. The first column has ARMA with GARCH model estimates which we use as a benchmark case.[13] As one can see in other columns, all coefficients of uncertainty measures are negative and significant.[14] Findings suggest that total and idiosyncratic uncertainty measures lead IPI by two months whereas aggregate uncertainty leads by five months. This lead structure is similar to the results of the VAR analysis by Bloom (2009). In addition, the latter has a higher significance among all three measures.

In order to see the effects of uncertainty shocks to economic activity, we draw impulse response functions[15] in Figure IV. As can be seen from the figure, aggregate uncertainty

[13] We use Schwarz Information Criterion to determine the proper model.

[14] Moreover, when we analyze the log-likelihood values, we can infer the significant effects of uncertainty on industrial production. Particularly, under null hypothesis that uncertainty is unrelated to industrial production ($\beta = 0$), twice the difference between log-likelihoods of different specifications is distributed as $\chi^2(1)$. We can see that while adding aggregate uncertainty is significant at 1 percent significance level, adding total or idiosyncratic uncertainty is significant at 5 percent.

[15] We first fit AR models to our uncertainty measures. Results are presented in Table VII. Then, by feeding one standard deviation shocks to the system, we obtain impulse response functions.

shock has the highest impact on industrial production. A one standard deviation of aggregate uncertainty shock causes a 0.5% decline in industrial production after five months. If we consider the prolonged effects of the shock, the model implies a 7.1% decline within a year. We should note that high persistence of the aggregate uncertainty ($AR(1)$ coefficient equals to 0.63, see Table VII) plays an important role in the size of this effect. Total and idiosyncratic uncertainty measures, however, have an approximately 5% decreasing effect on production within the first year.

5. Investment Under Uncertainty: An Ordered Probit Analysis

In this part of the paper, we use the panel dimension of our dataset to study the effect of uncertainty on firms' investment decisions. Employing our main intuition regarding the expectation errors and uncertainty, we test the hypothesis that if a firm faces higher uncertainty then it defers its investment plans. Thus, we estimate an ordered probit model with random effects to investigate the impact of uncertainty on investment decisions. Specifically, we use $Uncertainty_t^{Aggregate}$ and W_{it}^2 (square of firm i expectation errors at time t) as specified in the methodology section above.

The Business Tendency Survey provides qualitative information on firms' expectations about their own future investment, demand and production changes, on the basis of which we construct investment, demand and production measures. Our measures of investment, demand and production expectations are based on the answers to the questions in Table VIII.

We create categorical ordered indicator variables I_{it}, d_{it}, s_{it} for each firm that denote whether the investment, demand and production expectations of a firm is *increase*, *remain unchanged* or *decrease* at time t. The indicator variables attain values of -1, 0 and 1, respectively. It is assumed that the investment expectation of a firm i at time t, I_{it}, depends on its expectation about firm specific demand, d_{it}, its expectation about firm specific production, s_{it}, its idiosyncratic uncertainty, W_{it}^2 and the aggregate uncertainty of the economy, $Uncertainty_t^{Aggregate}$ as well as some lags of these variables according to the conditional linear model. In particular, we employ the model:

$$\begin{aligned} I_{it}^{*} &= \sum_{j=0}^{12} \beta_{1j} W_{it-j}^{2} + \sum_{j=0}^{12} \beta_{2j} Uncertainty_{t-j}^{Aggregate} \\ &\quad + \sum_{j=0}^{12} \beta_{3j} d_{it-j} + \sum_{j=0}^{12} \beta_{4j} s_{it-j} + \varepsilon_{it}, \end{aligned} \tag{23}$$

where ε_{it} is a normally distributed random error with mean 0 and variance σ_{ε} capturing unmeasured and unobservable effects on investment changes. Since the actual investment growth is a latent variable that is not directly observable, the investment growth I_{it} is assumed to be related to the latent investment variable I_{it}^{*} in the following manner.

$$I_{it} = \begin{cases} 1, & I_{it}^{*} > \mu_2 \\ 0, & \mu_1 < I_{it}^{*} < \mu_2 \\ -1, & I_{it}^{*} < \mu_1 \end{cases} \tag{24}$$

where μ_1 and μ_2 represent thresholds to be estimated along with the parameters $\beta_{1j}, \beta_{2j}, \beta_{3j}$ and β_{4j}s. For identification purposes, we set $\sigma_{\varepsilon} = 1$. Given the assumption that the error term is normally distributed, the probabilities associated with the coded responses of the model are calculated as follows.

$$
\begin{aligned}
Pr(I_{it}=-1) &= Pr(I_{it}^{*}<\mu_1) \\
&= Pr(\sum_{j=0}^{12}\beta_{1j}W_{it-j}^2+\sum_{j=0}^{12}\beta_{2j}Uncertainty_{t-j}^{Aggregate} \\
&\quad +\sum_{j=0}^{12}\beta_{3j}d_{it-j}+\sum_{j=0}^{12}\beta_{4j}s_{it-j}+\varepsilon_{it}<\mu_1) \\
&= \Phi(\mu_1-\sum_{j=0}^{12}\beta_{1j}W_{it-j}^2-\sum_{j=0}^{12}\beta_{2j}Uncertainty_{t-j}^{Aggregate} \\
&\quad -\sum_{j=0}^{12}\beta_{3j}d_{it-j}-\sum_{j=0}^{12}\beta_{4j}s_{it-j})
\end{aligned}
\tag{25}
$$

where $Pr(I_{it}=k)$ is the probability that firm i responds in manner k, and $\Phi(.)$ is the standard normal cumulative distribution function.[16]

The estimation results for the ordered probit model is reported in Table IX. Due to the nonlinearity of the ordered probit model, the estimated parameters cannot be interpreted as marginal effects. Thus, from the estimation results, we can only interpret the sign of the effects, not the magnitudes. Table IX suggests both aggregate and idiosyncratic uncertainties have a negative effect on investment plans as theory predicts.

To analyze the extent of the impact of demand and production expectations and aggregate and idiosyncratic uncertainty on the investment decisions, we calculate the probabilities for different possible values for d_{it}, s_{it}, W_{it}^2 and $Uncertainty_t^{Aggregate}$. The calculated probabilities are reported in Table X. It follows from this table that there are asymmetries in the investment decision to aggregate and idiosyncratic uncertainty changes. Under positive demand and supply conditions, an increase in the firm specific uncertainty decreases the probability of making new investment decision from 34 percent to 22 percent and increases the probability of discarding new investment decision from 16 percent to 25 percent. Under the same conditions, an increase in the aggregate uncertainty decreases the probability of making new investment decision from 34 percent

[16] Other probability values $Pr(I_{it}=0)$ and $Pr(I_{it}=1)$ can be computed in a similar fashion.

to 10 percent and increases the probability of discarding new investment decision from 16 to 44 percent. Apparently, the effect of aggregate uncertainty on the probability of an investment decision is much stronger than the effect of idiosyncratic uncertainty. We find similar results under negative demand and supply conditions.

6. Conclusion

There are three contributions of this paper. First, we form three measures of uncertainty from a survey data of firms which is based on firms' expectation errors. We assume that firms make expectation errors because of uncertainty in the economy. One advantage of our measures is that it is intuitively appealing that expectation errors change with the level of uncertainty. If there were no uncertainty, there would not be any expectation errors. Another advantage of this measure is its coverage of economically large and active firms. What really matters for the real economy is what the economically active agents expect. We go further and separate total uncertainty into two components. We name one of the components as "idiosyncratic uncertainty" and the other as "aggregate uncertainty". Idiosyncratic uncertainty is the variance of expectation errors made across firms. One implication of idiosyncratic uncertainty is that when all the firms make the same expectation error it implies zero uncertainty. On the other hand, aggregate uncertainty is defined as the square of the average expectation error made across firms. Consequently, the aggregate uncertainty measures more uncertainty if more firms make similar expectation errors.

Our second contribution is the analysis of the relationship between uncertainty measures that we develop and several measures of economic activity. The cross correlations show strong negative relations between our uncertainty measures and economic activity. Furthermore, the econometric analysis shows that the quantitative effect of uncertainty on production is large. In particular, we show that a one standard deviation increase in aggregate uncertainty is followed by a 0.5 percent decline in year-on-year change of IPI on impact. The prolonged effect reaches 7.1 percent in a year. The effects of idiosyncratic and total uncertainty are smaller but still reach to 5 percent.

Finally, we exploit the panel dimension of our dataset to provide evidence on the significant effects of aggregate and idiosyncratic uncertainty on firms' investment decisions. According to our findings, under positive demand and supply conditions, an increase in the aggregate uncertainty decreases the probability of making new investment decision by 71 percent and increases the probability of discarding new investment decision by 175 percent while an increase in the firm specific uncertainty decreases the probability of making new investment decision by 35 percent and increases the probability of discarding new investment decision by 56 percent. We find similar results under negative demand and supply conditions.

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AppendixA. Other Uncertainty Measures

Performances of the proposed uncertainty measures are compared with some other uncertainty measures used widely in the literature. In general, volatilities of several variables have been used as alternative uncertainty measures in the literature. Among them, stock market volatility and exchange rate volatility are the most common ones. In this study, we use volatilities (standard deviations) of the changes in exchange rate (e_t) and Istanbul Stock Exchange market index returns (s_t), and level of EMBI spread ($Embi_t$) as alternative uncertainty measures.

We report the cross-correlations of the alternative uncertainty measures with the economic activity in Table A.1. It can be seen that all the alternative measures have negative correlations with IPI and lead IPI with two to four months lag. Evidence from cross correlations show that our aggregate uncertainty measure has the strongest relationship with IPI.

In Table A.2 we report the results of Granger Causality tests of alternative uncertainty measures with IPI. Test results reveal that there are unidirectional causalities running from volatilities of exchange rate, stock market and EMBI spread to IPI.

Table I: Survey Size and Matching Rate

	Whole Sample		Paired Sample		Matching Rate	
Statistic	Period 1*	Period 2	Period 1	Period 2	Period 1	Period 2
Mean	343.8	1465.3	266.7	1233.2	78.4%	85.7%
Median	266.5	1524	217.5	1266.5	78.9%	86.1%
Minimum	199	962	151	789	67.0%	80.2%
Maximum	594	1978	465	1755	87.7%	91.1%
Standard Deviation	126.0	267.3	90.9	241.0	4.1%	3.0%

* Period 1 is the pre-harmonization period dating from 12/1987 to 12/2006 and Period 2 is the post-harmonization, from 01/2007 to 09/2010.

Table II: Questions

Question Number	Question	Answer Choices
Question 5	*How do you expect your production to develop over the next 3 months? It will...*	{Increase, Remain unchanged, Decrease, No Answer}
Question 1	*How has your production developed over the past 3 months? It has...*	{Increased, Remained unchanged, Decreased, No Answer}

Table III: Weights of Expectation Errors

		Development over the last 3 months (t+3)		
		Increased	*Remained unchanged*	*Decreased*
Expectations over the next 3 months (t)	*Increase*	0	-1/2	-1
	Remain unchanged	1/2	0	-1/2
	Decreased	1	1/2	0

Table IV: Cross Correlations of Uncertainty Measures with Economic Activity

		$t-6$	$t-5$	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$
IPI_t	$Uncertainty_t^{Total}$	−0.02	−0.04	−0.09	−0.13	−0.17	−0.21	−0.24	−0.25	−0.33	−0.36	−0.36	**−0.40**	−0.39
	$Uncertainty_t^{Idio.}$	−0.05	−0.07	−0.12	−0.16	−0.19	−0.24	−0.25	−0.23	**−0.29**	−0.28	−0.25	−0.28	−0.27
	$Uncertainty_t^{Agg.}$	0.07	0.05	0.03	0.01	−0.02	−0.05	−0.11	−0.18	−0.27	−0.39	−0.45	**−0.51**	−0.50
$I_t{}^*$	$Uncertainty_t^{Total}$	−0.01	0.04	0.12	0.15	0.08	−0.11	−0.30	−0.42	**−0.46**	−0.40	−0.25	−0.17	−0.10
	$Uncertainty_t^{Idio.}$	0.02	0.06	0.12	0.13	0.04	−0.14	−0.30	**−0.37**	−0.35	−0.27	−0.13	−0.10	−0.10
	$Uncertainty_t^{Agg.}$	−0.07	−0.03	0.06	0.13	0.15	0.02	−0.17	−0.37	−0.52	**−0.54**	−0.44	−0.27	−0.05
Ψ_t	$Uncertainty_t^{Total}$	0.14	0.10	0.05	0.01	−0.02	−0.05	−0.08	−0.13	−0.20	−0.24	−0.25	**−0.26**	−0.24
	$Uncertainty_t^{Idio.}$	0.12	0.08	0.03	0.00	−0.04	−0.05	−0.06	−0.08	−0.11	−0.11	−0.12	**−0.13**	−0.11
	$Uncertainty_t^{Agg.}$	0.14	0.11	0.09	0.05	0.03	−0.02	−0.08	−0.20	−0.33	−0.43	−0.46	**−0.46**	−0.46
Ω_t	$Uncertainty_t^{Total}$	0.16	0.12	0.07	0.03	−0.01	−0.06	−0.06	−0.11	−0.17	**−0.20**	−0.19	−0.15	−0.09
	$Uncertainty_t^{Idio.}$	0.13	0.10	0.06	0.03	−0.02	−0.07	−0.04	−0.03	−0.04	−0.04	−0.02	0.00	0.05
	$Uncertainty_t^{Agg.}$	0.15	0.11	0.07	0.04	0.02	−0.01	−0.08	−0.24	−0.42	**−0.52**	−0.52	−0.47	−0.41

Notes:
Variables are defined as,
IPI_t: Industrial production index, adjusted for calendar day effects, year-on-year change, source TURKSTAT
I_t: Investment component of GDP, constant prices, year-on-year change, source TURKSTAT
Ψ_t: Firms' 12-month expectations of own investment, balance from BTS data, source CBRT
Ω_t: Firms' 3-month expectations of own employment, balance from BTS data, source CBRT
* Because investment data is quarterly, we used quarterly averages of uncertainty measures.

Table V: Granger Causality Tests of Uncertainty Measures with Economic Activity

Var. X	Var. Y	Causality	F-statistic	Prob.	Results
IPI_t	$Uncertainty_t^{Total}$	$X \Rightarrow Y^a$	0.82	0.44	$Uncertainty_t^{Total} \Rightarrow IPI_t$
		$Y \Rightarrow X^b$	6.07	0.00	
	$Uncertainty_t^{Idio.}$	$X \Rightarrow Y$	1.64	0.20	$Uncertainty_t^{Idio.} \Rightarrow IPI_t$
		$Y \Rightarrow X$	3.69	0.03	
	$Uncertainty_t^{Agg.}$	$X \Rightarrow Y$	0.72	0.97	$Uncertainty_t^{Agg.} \Rightarrow IPI_t$
		$Y \Rightarrow X$	8.75	0.00	
Ψ_t	$Uncertainty_t^{Total}$	$X \Rightarrow Y$	0.80	0.49	$Uncertainty_t^{Total} \Rightarrow \Psi_t$
		$Y \Rightarrow X$	4.31	0.01	
	$Uncertainty_t^{Idio.}$	$X \Rightarrow Y$	0.00	1.00	No causal relation
		$Y \Rightarrow X$	1.47	0.23	
	$Uncertainty_t^{Agg.}$	$X \Rightarrow Y$	0.59	0.67	$Uncertainty_t^{Agg.} \Rightarrow \Psi_t$
		$Y \Rightarrow X$	15.21	0.00	
Ω_t	$Uncertainty_t^{Total}$	$X \Rightarrow Y$	1.60	0.15	$Uncertainty_t^{Total} \Rightarrow \Omega_t$
		$Y \Rightarrow X$	2.98	0.01	
	$Uncertainty_t^{Idio.}$	$X \Rightarrow Y$	1.95	0.10	No causal relation
		$Y \Rightarrow X$	1.26	0.08	
	$Uncertainty_t^{Agg.}$	$X \Rightarrow Y$	0.15	0.86	$Uncertainty_t^{Agg.} \Rightarrow \Omega_t$
		$Y \Rightarrow X$	36.59	0.00	

Notes:
Variables are defined as,
IPI_t: Industrial production index, adjusted for calendar day effects, year-on-year change, source TURKSTAT
Ψ_t: Firms' 12-month expectations of own investment, balance from BTS data, source CBRT
Ω_t: Firms' 3-month expectations of own employment, balance from BTS data, source CBRT
[a] H_0: X does not Granger cause Y.
[b] H_0: Y does not Granger cause X.

Table VI: Economic Activity and Uncertainty

	$y_t = IPI_t^*$			
y_{t-1}	0.82	0.83	0.84	0.77
	(0.06)***	(0.05)***	(0.05)***	(0.05)***
y_{t-2}	-0.08	-0.07	-0.07	-0.05
	(0.08)	(0.08)	(0.08)	(0.08)
y_{t-3}	0.04	0.02	0.02	0.03
	(0.08)	(0.07)	(0.07)	(0.08)
y_{t-4}	0.00	0.00	0.01	0.02
	(0.07)	(0.07)	(0.07)	(0.06)
y_{t-5}	0.15	0.13	0.13	0.12
	(0.05)**	(0.05)**	(0.05)***	(0.05)**
$MA(12)$	-0.86	-0.84	-0.85	-0.86
	(0.02)***	(0.02)***	(0.02)***	(0.02)***
$Uncertainty_{t-2}^{Total}$		-0.13		
		(0.05)**		
$Uncertainty_{t-2}^{Idio.}$			-0.14	
			(0.06)**	
$Uncertainty_{t-5}^{Agg.}$				-0.62
				(0.21)***
Constant	0.40	2.46	2.56	0.79
	(0.15)***	(0.85)***	(0.87)***	(0.18)***
$ARCH(1)$	0.04	0.04	0.04	0.06
	(0.01)***	(0.01)***	(0.01)***	(0.02)***
$GARCH(1)$	1.62	1.64	1.64	1.56
	(0.03)***	(0.02)***	(0.02)***	(0.06)***
$GARCH(2)$	-0.95	-0.98	-0.98	-0.87
	(0.02)***	(0.02)***	(0.02)***	(0.05)***
Constant	4.70	4.62	4.62	3.97
	(0.51)***	(0.47)***	(0.47)***	(0.47)***
Number of Observations	254	254	254	254
Log Likelihood	-705.1	-702.7	-702.6	-700.4
R^2	0.79	0.79	0.79	0.80

Notes: (1) Dependent variable is IPI, adjusted for calendar day effects, year-on-year changes. (2) The numbers in parentheses are standard errors and (*), (**) and (***) denote significance at 10%, 5% and 1%, respectively.

Table VII: Autoregressive Properties of Uncertainty Measures

y_t	$Uncertainty^{Total}$	$Uncertainty^{Idio.}$	$Uncertainty^{Agg.}$
y_{t-1}	0.53	0.41	0.63
	(0.06)***	(0.06)***	(0.05)***
y_{t-2}	0.14	0.13	
	(0.06)**	(0.07)**	
y_{t-3}		0.16	
		(0.06)***	
Constant	5.00	4.36	0.17
	(0.81)***	(0.89)***	(0.05)***
Number of Observations	269	268	270
R^2	0.39	0.35	0.40

Notes: (1) The numbers in parentheses are standard errors and (*), (**) and (***) denote significance at 10%, 5% and 1%, respectively.

Table VIII: Questions

	Question	Answer Choices
Question 5	*How do you expect your production to develop over the next 3 months? It will...*	{Increase, Remain unchanged, Decrease, No Answer}
Question 17	*How do you expect your overall orders to develop over the next 3 months? It will...*	{Increase, Remain unchanged, Decrease, No Answer}
Question 23	*Compared to the last 12 months, how do you expect your fixed investment expenditure to change over the next 12 months? It will...*	{Increase, Remain unchanged, Decrease, No Answer}

Table IX: Ordered Probit Estimation Results

	Coefficient	p-value
W_{it}^2	-0.35	0.03
$Unc._{t-5}^{Macro}$	-0.86	0.00
d_{it}	0.18	0.00
s_{it}	0.24	0.00
μ_1	-0.59	0.00
μ_2	0.84	0.00
Number of Observations	76,327	

Table X: Ordered Probit Estimation Results

$Pr(I_{it} = 1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 0, d_{it} = 1, s_{it} = 1)$	0.34
$Pr(I_{it} = 1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 0, d_{it} = 1, s_{it} = 1)$	0.22
$Pr(I_{it} = 1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 1, d_{it} = 1, s_{it} = 1)$	0.10
$Pr(I_{it} = 1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 1, d_{it} = 1, s_{it} = 1)$	0.05
$Pr(I_{it} = -1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 0, d_{it} = 1, s_{it} = 1)$	0.16
$Pr(I_{it} = -1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 0, d_{it} = 1, s_{it} = 1)$	0.25
$Pr(I_{it} = -1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 1, d_{it} = 1, s_{it} = 1)$	0.44
$Pr(I_{it} = -1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 1, d_{it} = 1, s_{it} = 1)$	0.58
$Pr(I_{it} = 1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 0, d_{it} = -1, s_{it} = -1)$	0.10
$Pr(I_{it} = 1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 0, d_{it} = -1, s_{it} = -1)$	0.05
$Pr(I_{it} = 1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 1, d_{it} = -1, s_{it} = -1)$	0.02
$Pr(I_{it} = 1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 1, d_{it} = -1, s_{it} = -1)$	0.01
$Pr(I_{it} = -1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 0, d_{it} = -1, s_{it} = -1)$	0.43
$Pr(I_{it} = -1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 0, d_{it} = -1, s_{it} = -1)$	0.57
$Pr(I_{it} = -1 \vert W_{it}^2 = 0, Unc._{t-5}^{Macro} = 1, d_{it} = -1, s_{it} = -1)$	0.76
$Pr(I_{it} = -1 \vert W_{it}^2 = 1, Unc._{t-5}^{Macro} = 1, d_{it} = -1, s_{it} = -1)$	0.85

Table A.1: Cross Correlations of Alternative Uncertainty Measures with Economic Activity

	$t-6$	$t-5$	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$
$Std(\Delta e_t)$	0.08	0.02	0.02	−0.04	−0.17	−0.18	−0.23	−0.29	−0.34	**−0.35**	−0.30	−0.29	−0.25
$Std(\Delta s_t)$	0.01	−0.01	−0.01	−0.04	−0.06	−0.10	−0.18	−0.24	−0.27	−0.32	**−0.37**	−0.36	−0.31
$Embi_t{}^*$	0.08	0.09	0.16	0.19	0.13	0.11	0.07	−0.03	−0.09	−0.14	−0.19	−0.17	**−0.20**

Notes:
Variables are defined as,
$Std(\Delta e_t)$: Nominal US Dollar/Turkish Lira exchange rate, monthly standard deviations of daily changes, source CBRT.
$Std(\Delta s_t)$: Istanbul Stock Exchange ISE100 Index, monthly standard deviations of daily returns, source ISE.
$Embi_t$: Emerging Market Bond Index Global, changes in monthly spread averages, source Bloomberg.
* Available data starts from January 1998.

Table A.2: Granger Causality Tests of Uncertainty Measures with Economic Activity

Var. X	Var. Y	Causality	F-statistic	Prob.	Results
IPI_t	$Std(\Delta e_t)$	$X \Rightarrow Y^a$	1.07	0.34	$e_t \Rightarrow IPI_t$
		$Y \Rightarrow X^b$	7.46	0.00	
	$Std(\Delta s_t)$	$X \Rightarrow Y$	0.04	0.96	$s_t \Rightarrow IPI_t$
		$Y \Rightarrow X$	4.70	0.01	
	$Embi_t$	$X \Rightarrow Y$	1.26	0.29	$Embi_t \Rightarrow IPI_t$
		$Y \Rightarrow X$	4.03	0.02	

Notes:
Variables are defined as,
$Std(\Delta e_t)$: Nominal US Dollar/Turkish Lira exchange rate, monthly standard deviations of daily changes, source CBRT.
$Std(\Delta s_t)$: Istanbul Stock Exchange ISE100 Index, monthly standard deviations of daily returns, source ISE.
$Embi_t$: Emerging Market Bond Index Global, changes in monthly spread averages, source Bloomberg.
[a] H_0: X does not Granger cause Y.
[b] H_0: Y does not Granger cause X.

Figure I: Average Squared Expectation Errors as a Function of θ_t

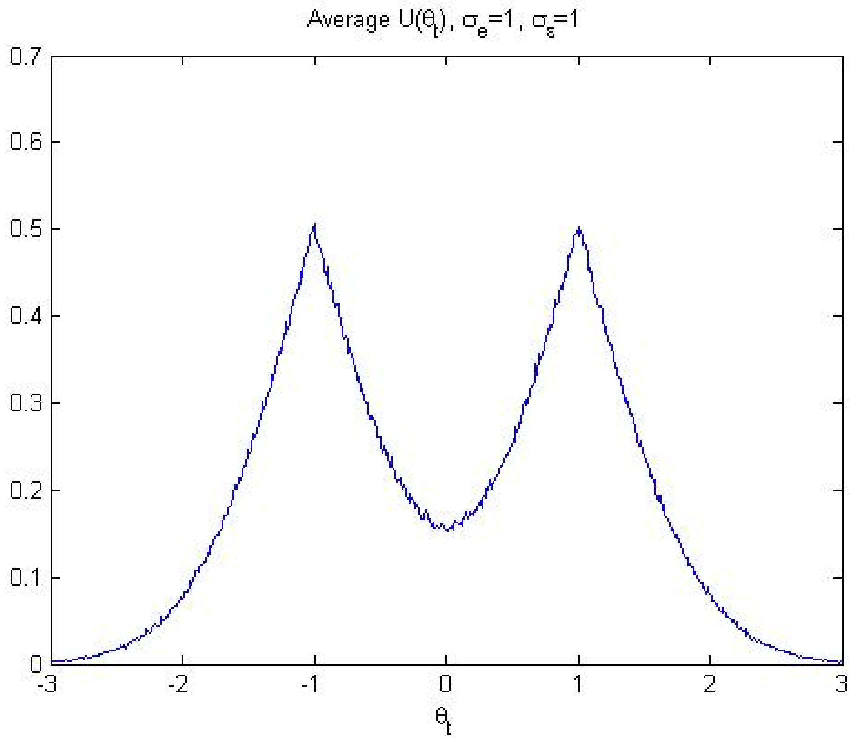


Figure II: Average Squared Expectation Errors as a Function of σ_e and σ_ϵ

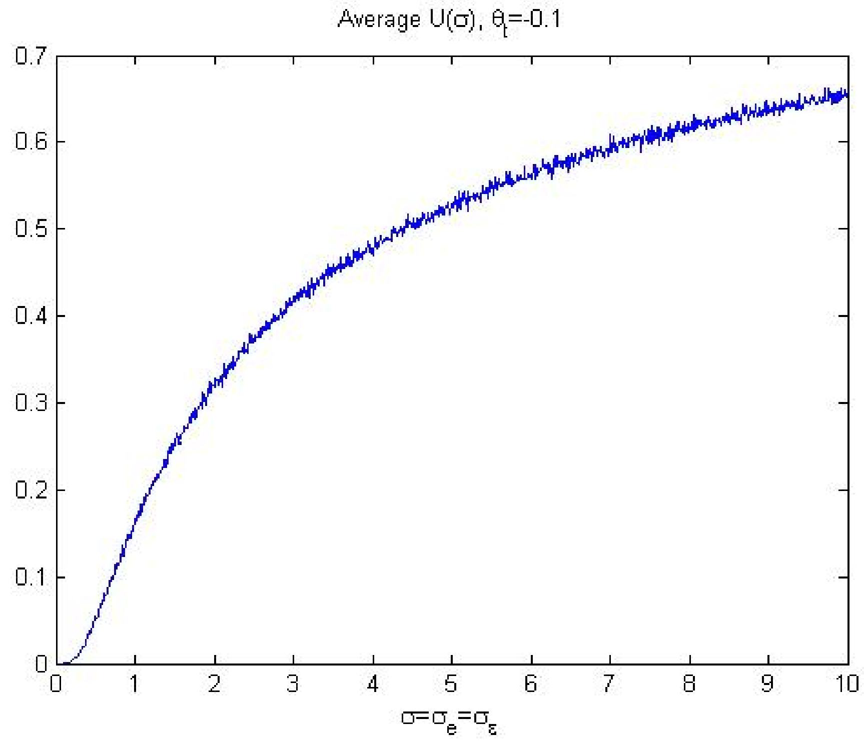
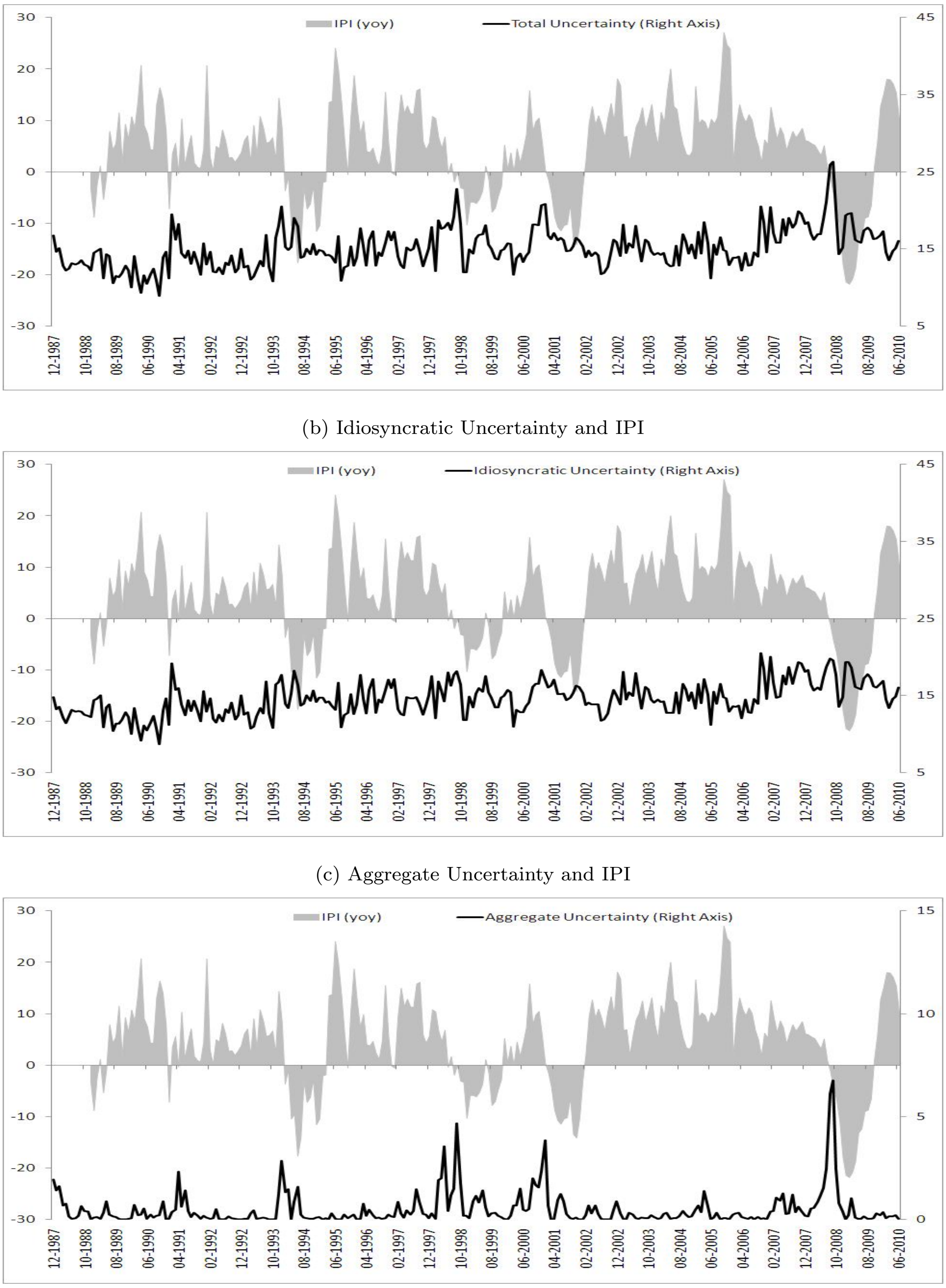


Figure III: Uncertainty and IPI

(a) Total Uncertainty and IPI

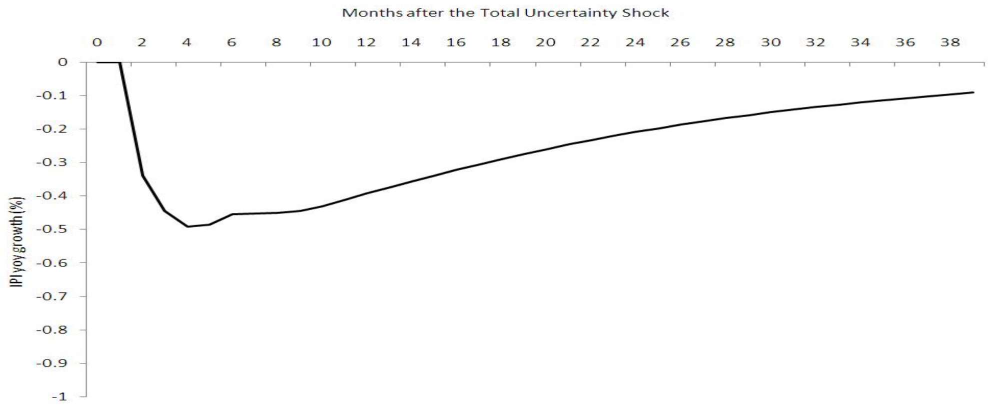


(b) Idiosyncratic Uncertainty and IPI

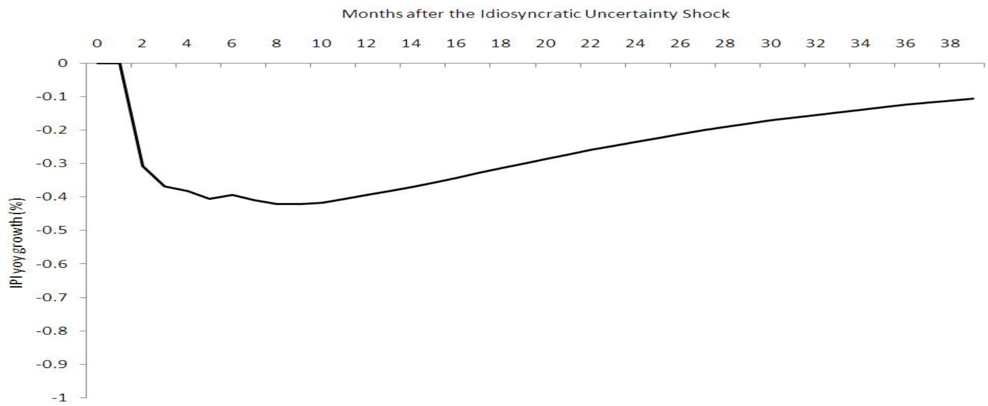
(c) Aggregate Uncertainty and IPI

Figure IV: Impulse Responses of IPI to One Standard Deviation Uncertainty Shocks

(a) Total Uncertainty and IPI



(b) Idiosyncratic Uncertainty and IPI



(c) Aggregate Uncertainty and IPI

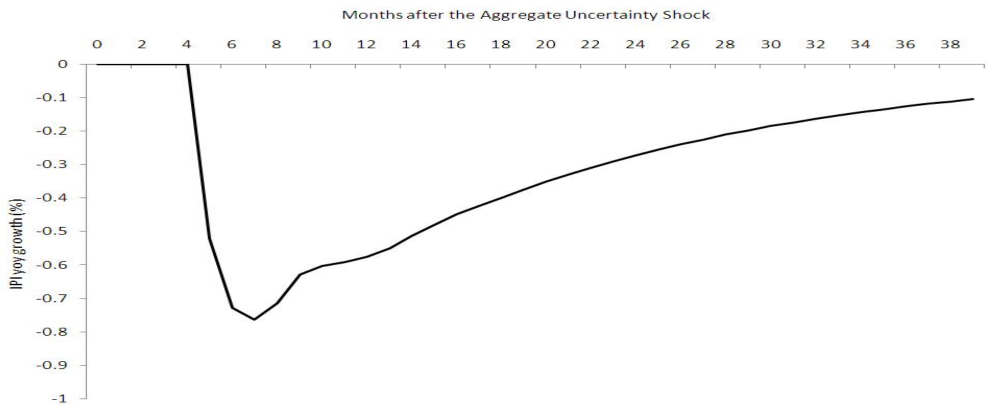
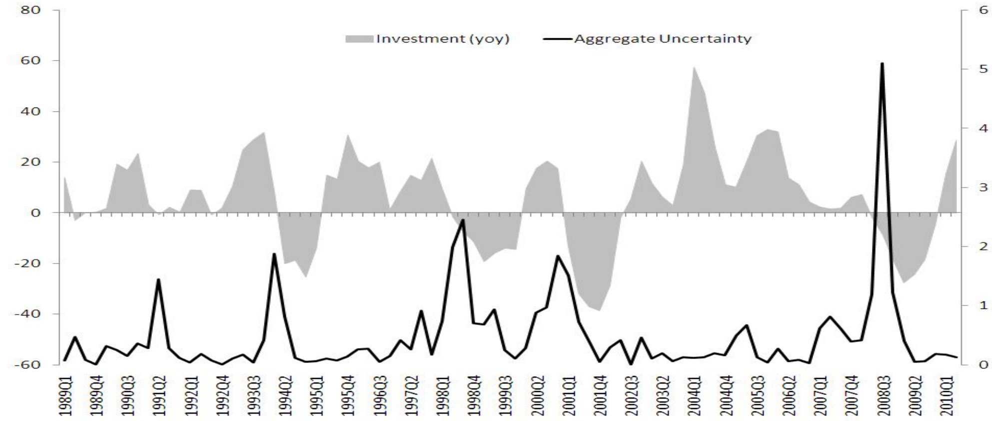
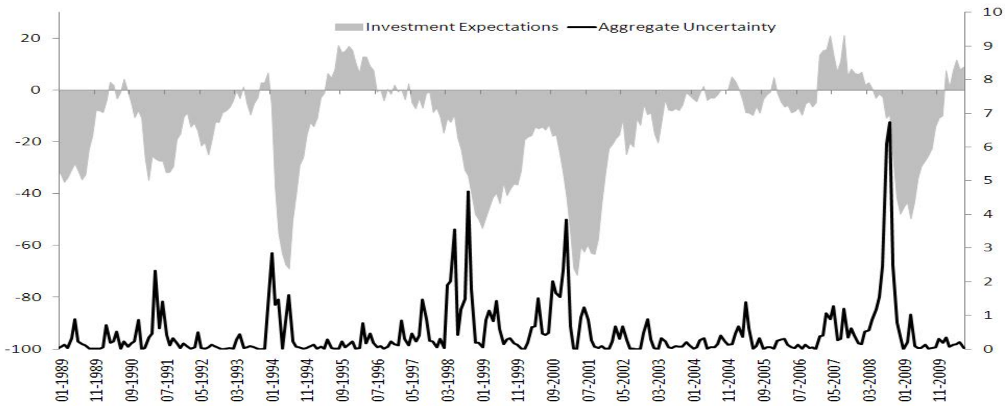


Figure V: Aggregate Uncertainty and Other Economic Activity Variables

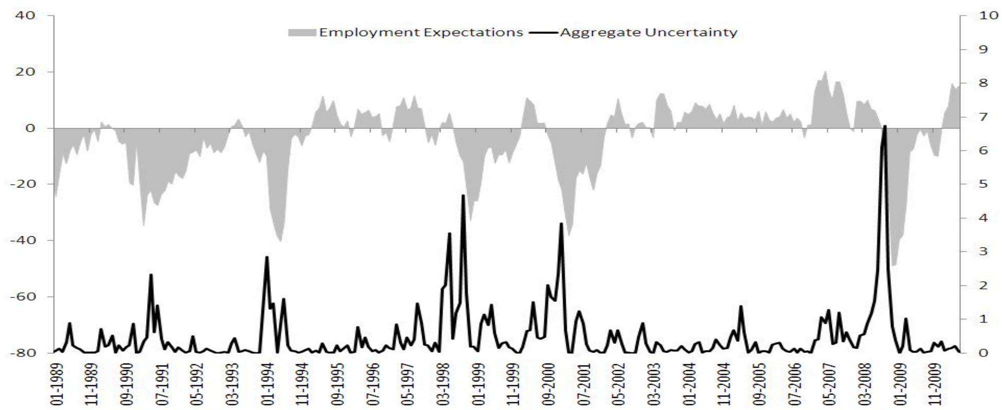
(a) Aggregate Uncertainty and Investment



(b) Aggregate Uncertainty and Expectations of Investment



(c) Aggregate Uncertainty and Expectations of Employment



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