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ABSTRACT

Communism in East Germany sought to dampen the effect of market forces on firm productivity for nearly 40 years. How did East German firms respond to the free market after being thrust into it in 1990? We use a formal learning model and German business survey data to analyze the lasting impact of this far-reaching treatment on the way firms in former East Germany predicted their own productivity relative to firms in former West Germany during the two decades since Reunification. We find in confirmation of our formal model's predictions, that Eastern firms forecast productivity less accurately, particularly in dynamic and uncertain markets, but that the gap gradually closed over 12 to 13 years. Second, by analyzing the direction of firm level errors in conjunction with contemporaneous market signals we find that, in the years immediately following Reunification, Eastern firms estimate the market's role as generally less potent than Western firm do, an observation consistent with overweighting experiences from the communist era; however, over roughly 14 years both converge to the same (incorrect) overestimate of the market's role on their productivity.

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1 Introduction

> "This is no ordinary reading material... It contains your fate. In its pages you will see your future. This is the government's law on the Five Year Plan to develop the German Democratic Republic... Industrial production will more than double by 1955 when compared to 1936... All foodstuffs and industrial goods will be available at fixed and affordable prices...Thanks to the plan we here lay before you, you are in the position to follow from quarter to quarter how industries, crafts, commerce, agriculture, forestry and the health system will develop."—Walter Ulbricht, *Gesetz über den Fünfjahrplan zur Entwicklung der Volkswirtschaft der Deutschen Demokratischen Republik 1951-1955.*[1]

The above quote from the introduction of East Germany's first Five Year Plan, suggests that managing a firm in the master-planned economy of the East differed significantly from doing so in the free market economy, at least in part, because Eastern social planners explicitly worked to remove the variability of the free market from their economy. In this paper, we examine the lingering role of communism on the way former East German businesses forecast their future business performance—how long did it take for firms located in former East Germany to learn how market forces impacted their productivity?

Generally speaking, do the acquired knowledge, techniques and heuristics of businesses in one culture differ systematically from those who did it in another culture? How persistent are those effects? When a businessman receives new information he combines that knowledge with his prior information and beliefs to form a prognosis about the future. Different businessmen, even under the same legal and regulatory institutions, confronted with the same new information may come to entirely different conclusions about its impact. The source of their differing priors and the methods by which they update includes their differing experience, education as far back as childhood, culture, even their genes. In general, these issues are examined using cross-country evidence. This makes it difficult to disentangle the separate effects of culture, institutions and ethnicity, because these are so intertwined at the national level.

We take advantage of a unique natural experiment, namely the temporary division of Germany into two distinct countries. This event is peculiar in that a relatively homogenous population, ethnically and institutionally, was exogenously separated in 1949 and "treated" with different institutions until 1990, when the two countries were reintegrated and institutions re-homogenized. For over four decades, the economy of East Germany was master-planned and significant resources were expended to develop East German culture distinct from their Western neighbor's. There is a burgeoning literature on the cultural imprinting of individuals, including several studies that take advantage of the natural experiment of German separation (Alesina and Fuchs-Schündeln, 2007; van Hoorn and Maseland, 2010; Heineck and Süssmuth, 2010). Often, this literature links individual values to overall economic performance (via entrepreneurship) (Bauernschuster et al., 2012), trying to explain the relatively poor economic performance of the East. The evidence on differing values between East and West is mixed, and the link between individual values and economic performance is contested (van Hoorn and Maseland, 2010). We analyze firm behavior, which may relate to overall economic performance closer than individual behavior, and show that this cultural treatment systematically changed the way firms

[1] *Translation: Law on the Five Year Plan Covering the Economic Development of the German Democratic Republic 1951-1955.*

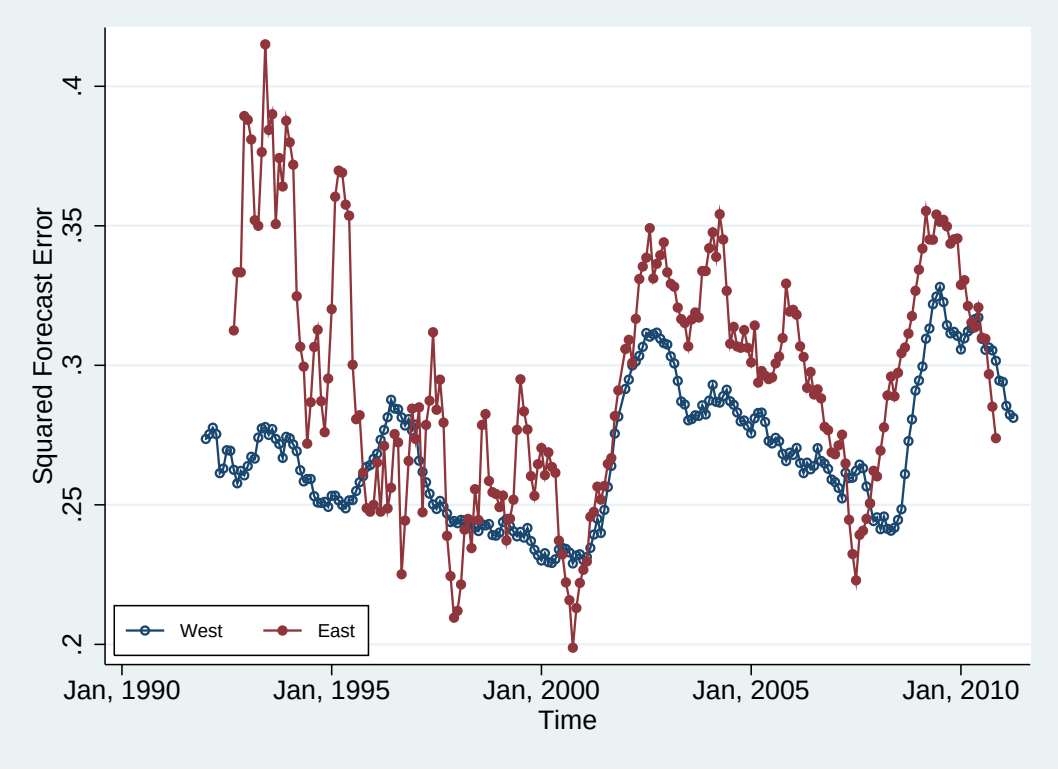

Figure 1: This graph plots the monthly averages of the squared forecast error for the East and West of Germany.

perceive the future. Economics research on culture and firm level perception of the future is scant. In one exception, Nerlove (1983) compares distributions of firm productivity (conditional on prior forecasts) between Germany and France. He finds that these distributions are less stable over time in France and attributes this to "greater changes taking place in the French economy" (p. 1267). Our narrative is similar in the sense that German reunification increased economic uncertainty for firms in the East.

Since 1949 the Ifo Institute in Munich has surveyed thousands of West German firms on a monthly basis about their near-term productivity expectations and actual realizations. Beginning in 1991, the Institute expanded its survey to cover firms in former East Germany. We use this data to compute forecast errors (*i.e.* actual production minus forecast) and compare the forecast accuracy of West and East German firms over time.

Figure 1 depicts the average squared error (*i.e.* error magnitude) of West German and East German productivity forecasts from 1992 to 2010 (12 month moving average). The figure reveals that East German forecasts are less accurate (*i.e.* errors are larger). This is particularly clear in the years immediately following Reunification in 1990. This casual observation motivates our formal analysis.

We develop a simple theory of organizational learning to explain this phenomena. In the model, firms observe signals of market states critical to firm productivity; however, they do not know precisely how market states impact firm productivity—the production function is not precisely known. Rather, they

learn the role of the market for their own productivity over time. We conjecture that East German firms received a shock with respect to the role of market factors when Germany reunified. Being inexperienced with the free market, we hypothesize that the quality of their productivity forecasts was worse. Further, since understanding the market's role is most crucial to predicting productivity changes when the market is likely to change, we further hypothesize that inexperienced and Eastern firms were most susceptible to forecast errors in dynamic markets. Finally, since learning the markets role is most difficult where information is most noisy, we hypothesize that firms in historically uncertain industries, forecasted less accurately. We find strong empirical support for all of these hypotheses.

Figure 2 depicts the average directional error by Eastern and Western firms. Positive errors indicate pessimism—firms produced more than anticipated. Negative errors indicate optimism—firms produced less than anticipated. The base formal model is based on fully rational learning. At any given time, *rational* learners imperfectly estimate the *model parameter* they are learning, but their errors would generally exhibit no systematic, directional bias. However, Figure 2 shows that Western firms' *productivity forecasts* are systematically optimistic over the sample period and that Eastern firms' *productivity forecasts* are even more optimistic than Western ones in the early years after Reunification, though they gradually converge to the same levels of optimism as Western firms. Psychologists have observed this "optimism bias" in many settings.[2] Economists, Kahneman and Lovallo (1993) discuss how this individual optimism may translate into organizational optimism. While this psychological phenomena probably influences the overall levels optimism we observe (both graphically and in our controlled regressions), what might explain the *difference* between the Eastern and Western forecast errors immediately following Reunification?

We conjecture that Eastern firms improperly overweighted their prior experiences under communism, where the market's role was minimal, to inform them of the role of the market after Reunification. Relaxing our assumption of full rationality, we extend the theoretical model to permit such learning biases. The model suggests that firms that systematically underestimate the market's role will forecast productivity pessimistically (too low) when market signals indicate positive change and optimistically (too high) when market signals indicate negative change. Intuitively, a firm that underestimates the importance of the market will not put enough weight on market signals when forecasting productivity: (1) Observing a very high market signal, such a firm should raise its estimates sharply but will not, and thus will tend to produce more than it had forecast—a pessimistic forecast. (2) Observing a very low market signal, such a firm should drop its estimates severely but will not, and thus will tend to produce less than it had forecast—an optimistic forecast. Thus, we hypothesize that these patterns exist for Eastern firms relative to Western ones. We find empirical support for this hypothesis too.

Although, the learning model makes no predictions regarding *differences* in baseline biases (*i.e.* those independent of the role of the market) our regressions reveal that after controlling for market effects, Eastern firms are strongly optimistic in their predictions of future productivity immediately following the collapse of communism. We speculate that these findings indicate another psychological effect: initial euphoria stemming from democratic and capitalistic reforms.

While we find evidence that these systematic differences between East and West German firm forecast errors diminished over time, they were surprisingly persistent—lasting well over a decade

[2]For example, psychologist Weinstein (1980) noted that college students are unrealistically optimistic about future life events. More recently, neuroscientists Sharot et al. (2007) have exposed associated physiological mechanisms in the brain and have tied (unrealistic) optimism to good psychological health.

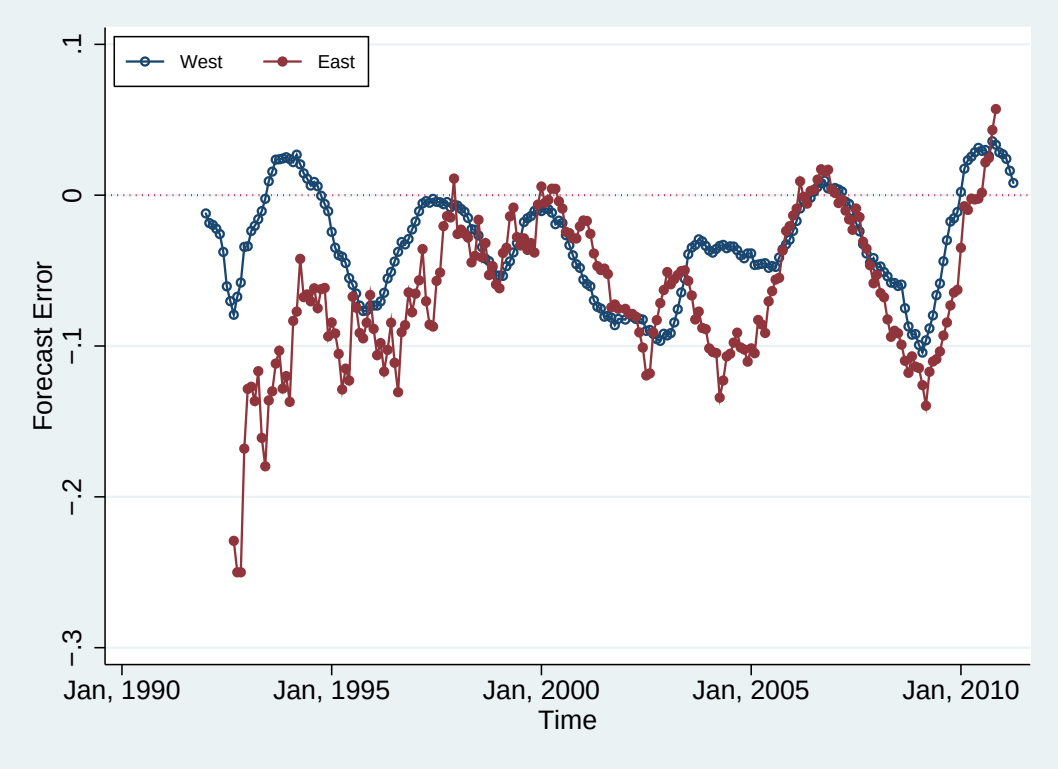

Figure 2: This graph plots the monthly average forecast errors for the East and West of Germany. The lower the number the more optimistic the forecast is.

after Reunification.

Finally, this convergence could happen in several ways. Learning could occur at the firm level—individual firms get better at forecasting with practice. Alternatively, learning could happen at the industry level through selective attrition—bad forecasters might be more likely to leave the market. We find that firm level forecasting improves with firm experience in our sample, in both East and West, though much faster in the East. This is consistent with our view that Eastern firms received a more dramatic shock to their understanding of the role of the market when abruptly introduced to the free market economy—early learning generally provides greater incremental gains to understanding than subsequent learning.

The remainder of the paper is organized as follows. In the next section we formally derive our hypotheses from a model. In Section 3 we map these hypotheses to empirical specifications. In Section 4 we describe our data. Results are presented in Section 5, and we conclude in Section 6.

2 Theory

In this section we derive empirically testable hypotheses from a formal model of learning. Figure 2 reveals that Eastern firms make systematically larger forecast errors in the years immediately following Reunification and gradually converge to similar error magnitudes as Western firms. But there are

potentially several reasons for this phenomena. We propose that it stems from Eastern firms gradually learning how the free market affects their productivity. A model of "learning the market's role" generates comparative statics relating indicators of market change to the magnitude of forecast errors, in a way that distinguishes our subsequent empirics from alternative explanations.

Next we investigate how this "learning the market's role" explanation might elucidate the *direction* of firms' forecast errors, especially differences between East and West. We conjecture that Eastern firms used prior experiences under communism to inform their posterior beliefs of the role of the market after Reunification too strongly. We formally show that this conjecture, if true, has distinct implications for the direction of forecast errors tied to dynamic market characteristics. We also express these predictions as empirical hypotheses, which we subsequently test.

2.1 Model

Suppose that the change in firm i's productivity at time t is given by $P_{it} = x_{it} + y_t c_i$, where x_{it} is the change in an unobserved firm i's (idiosyncratic) state, y_t is the change in a market state common to all firms (within an industry) and c_i is a positive firm specific, time invariant factor which relates change in market state to a change in firm productivity. Firm i observes x_{it}, but cannot observe y_t or c_i.

However, all firms receive signal $\hat{y}_t = y_t + \varepsilon_t$, where the noise is distributed $Normal\left(0, \sigma^2_{\varepsilon t}\right)$. We assume that y_t is distributed $Normal\left(0, \sigma^2_{yt}\right)$ and that firm i knows the true data generating processes (DGP) of y_t and ε_t such that firm i holds correct posterior beliefs about y_t. It is well-known that the mean and variance of correct posterior beliefs over y_t are

$$\bar{y}_t = E\left[y_t | \hat{y}_t\right] = \frac{\sigma^2_{yt}}{\sigma^2_{yt} + \sigma^2_{\varepsilon t}} \hat{y}_t \tag{1}$$

and

$$\bar{\sigma}^2_{yt} = Var\left[y_t | \hat{y}_t\right] = \frac{\sigma^2_{yt}\sigma^2_{\varepsilon t}}{\sigma^2_{yt} + \sigma^2_{\varepsilon t}} \tag{2}$$

respectively.

The firm holds prior beliefs, possibly *incorrect*, about c_i and updates these beliefs based on the realized $P_{i,t}$, which is observed at the end of period t, as well as *past* productivity and signal realizations (Note that the current signal realization $\hat{y}_t$ is independent of beliefs over c_i at the beginning of period t). Denote the mean and variance of firm i's posterior beliefs over c_i as $\bar{c}_{it}$ and σ^2_{cit} respectively, conditioned on having observed all information available at the beginning of period t,

$$\Omega_{i,t} = \{P_{i,1}, \ldots, P_{i,t-1}, x_{i1}, \ldots, x_{it}, \hat{y}_1, \ldots, \hat{y}_t\}$$

The firm's estimate of performance conditional on the observed signals and the distribution of posterior beliefs is $\hat{P}_{it} = E\left[P_{it} | \Omega_{i,t}\right]$, a *random variable* with respect to the DGP.

Let $b_{it} = c_i - \bar{c}_{it}$ denote firm i's misjudgment or bias of the market's role at time t. Note that *if firm i's priors were correct*, then the expected squared bias would equal the variance of the belief distribution over c_i at time t:

$$E\left[b^2_{it}\right] = E\left[\left(c_i - \bar{c}_{it}\right)^2\right] = E\left[\left(c_i - E\left[c_i\right]\right)^2\right] = \sigma^2_{cit}$$

But since our model accommodates *wrong* priors on the part of the firm, the expected squared bias $E\left[b_{it}^2\right]$ (rather than σ_{cit}^2) will be the key measure in our analysis of how well the firm has learned the role of the market.

Rather than explicating a particular learning process or making assumptions on the exact probability distributions of the market's role, we make three assumptions about how the squared bias of a firm would be affected by a general learning process for a broad class of distributions.

1. **Noisy Signals Impede Learning:** The noisier historical market signals are, the further their best guess of the market's role is from the true one. Formally, for all $\tau < t$, $E\left[\partial b_{it}^2/\partial \sigma_{\varepsilon\tau}^2\right] > 0$, where the expectation is over alternative histories. In this case, we mean that the variance of the signal noise in period τ is perturbed and the expectation of firm ι's squared bias, over all alternative histories for $\hat{y}_\tau$ leaving all other variable realizations fixed, is compared with the squared bias under the unperturbed history.

2. **Market Understanding Improves:** Over time, firms' learn their market factors with smaller biases. Formally, $E\left[\partial b_{it}^2/\partial t\right] < 0$ and for all i, $\lim_{t\to\infty} b_{it} = 0$, where expectation is over the set of alternative histories possible through adding an additional time period, holding the previous history fixed.

3. **East Understands Less than West:** Eastern firms have larger overall biases than Western firms. Formally, $E\left[b_{it}^2 \middle| i \in East\right] > E\left[b_{it}^2 \middle| i \in West\right]$, where the expectations are over the average histories of Eastern and Western firms respectively. Underlying this assumption is the fact that with the end of communism the role of the market for Eastern firms was significantly altered, as if Eastern firms drew new c_i's, with their introduction to the free market economy, which they had to begin learning from scratch. Of course, Western firms may also have experienced a shock at this time, but we assume this shock was relatively smaller.

2.2 Forecast Error Magnitude

Firm i's squared forecast error in period t is

$$\left(P_{it} - \hat{P}_{it}\right)^2 = \left(P_{it} - E\left[P_{it}|\Omega_{i,t}\right]\right)^2 = \left(P_{it} - \left(x_{it} + \bar{y}_t \bar{c}_{it}\right)\right)^2$$

The empiricist seeks to understand how firm i's forecast error magnitude varies with respect to market conditions together with our learning assumptions. She does not know x_{it}, y_t or c_i, but like firm i, she observes $\hat{y}_t$ and can use this information to improve her estimate of firm i's forecast error. Thus, from the perspective of the empiricist, the expected squared forecast error in period t (MSE_{it}, "mean squared error"), conditional on all observed information is

$$MSE_{it} = E\left[\left(P_{it} - \hat{P}_{it}\right)^2 \middle| \hat{y}_t\right] = E_{c_i}\left[E\left[\left(P_{it} - \hat{P}_{it}\right)^2 \middle| \hat{y}_t, c_i\right] \middle| \hat{y}_t\right]$$

where we have applied the Law of Iterated Expectations, conditioning on c_i. Considering just the

inner expectation and simplifying in several steps

$$\begin{aligned}
&E\left[\left(P_{it}-\hat{P}_{it}\right)^2\middle|\,\hat{y}_t,c_i\right]\\
&=E\left[\left(x_{it}+y_tc_i-(x_{it}+\bar{y}_t\bar{c}_{it})\right)^2\middle|\,\hat{y}_t,c_i\right]\\
&=E\left[\left(y_tc_i-\bar{y}_t\bar{c}_{it}\right)^2\middle|\,\hat{y}_t,c_i\right]\\
&=c_i^2E\left[y_t^2\middle|\,\hat{y}_t\right]-2c_i\bar{y}_t\bar{c}_{it}E\left[y_t\middle|\,\hat{y}_t\right]+\bar{y}_t^2\bar{c}_{it}^2\\
&=c_i^2\left(\bar{\sigma}_{yt}^2+\bar{y}_t^2\right)-2\bar{y}_t^2c_i\bar{c}_{it}+\bar{y}_t^2\bar{c}_{it}^2\\
&=c_i^2\bar{\sigma}_{yt}^2+\bar{y}_t^2\left(c_i-\bar{c}_{it}\right)^2
\end{aligned}$$

Substituting back into the outer expectation

$$MSE_{it}=E_{c_i}\left[c_i^2\bar{\sigma}_{yt}^2+\bar{y}_t^2\left(c_i-\bar{c}_{it}\right)^2\middle|\,\hat{y}_t\right]=\bar{\sigma}_{yt}^2E\left[c_i^2\right]+\bar{y}_t^2E\left[b_{it}^2\right] \tag{3}$$

where we have used the independence of $\bar{y}_t$ from c_i and $\bar{c}_{it}$.

Now we generate testable hypotheses relating to the forecast errors of Eastern and Western firms as they mature and encounter various market signals. In particular, these hypotheses will reflect comparative statics on equation (3).

Differentiating MSE_{it} with respect to t, we obtain

$$\frac{\partial MSE_{it}}{\partial t}=\bar{y}_t^2E\left[\frac{\partial b_{it}^2}{\partial t}\right]<0$$

where the inequality follows from the fact that firms' understanding about the market's role for their productivity probabilistically improves over time (Assumption 2). Thus,

Hypothesis 1 (Experience): *Less experienced firms make bigger forecast errors.*

Differencing $MSE_{it,\in West}$ and $MSE_{it,\in East}$, we obtain

$$\bar{y}_t^2\left(E\left[b_{it}^2\middle|\,i\in West\right]-E\left[b_{it}^2\middle|\,i\in East\right]\right)<0 \tag{4}$$

where the inequality follows from the fact that while all firms interpret the market signals similarly (*i.e.* $\bar{y}_t^2>0$ is identical for all firms), Eastern firms do not understand the role of the market for their productivity as well as Western firms (Assumption 3). Thus,

Hypothesis 2 (East): *Eastern firms make bigger forecast errors than Western firms.*

While useful, a number of alternative models might provide the two predictions derived above from our learning model. For instance, the inferior infrastructure of the East in the period immediately after the fall of communism might add a source of unpredictability in forecasting for Eastern firms. Thus, we generate several additional hypotheses that are distinct to learning the role of the market.

We first explore how forecasting in dynamic markets differs from more static situations; *e.g.* some markets shrink or grow, while others remain the same size. We measure market dynamism by the magnitude of changes in market states y_t. Since neither the firm nor the empiricist directly observe the market state, only an unbiased signal of it, we proxy for dynamic markets with $\hat{y}_t^2$, a measure of

the magnitude of the market signal. Taking the derivative of equation (3) with respect to the squared market signal,

$$\frac{\partial MSE_{it}}{\partial \hat{y}_t^2} = \frac{\partial \bar{\sigma}_{yt}^2}{\partial \hat{y}_t^2} E\left[c_i^2\right] + \frac{\partial \bar{y}_t^2}{\partial \hat{y}_t^2} E\left[b_{it}^2\right] > 0 \tag{5}$$

where the inequality follows from the facts that $\frac{\partial \bar{\sigma}_{yt}^2}{\partial \hat{y}_t^2} = 0$ and $\frac{\partial \bar{y}_t^2}{\partial \hat{y}_t^2} > 0$ (see equations (1) and (2)). Thus,

Hypothesis 3 (Market Dynamism): *All firms make bigger forecast errors in dynamic markets.*

The intuition behind Hypothesis 3 is that when the market change is unlikely (*i.e.* $\bar{y}_t^2 \approx 0$), misunderstanding the role of the market matters little to predicting productivity changes (formally, $\bar{y}_t^2 E\left[b_{it}^2\right] \approx 0$, for all finite $E\left[b_{it}^2\right]$). On the other hand, if market change is expected (*i.e.* $\bar{y}_t^2 \gg 0$), then understanding what it means for the firm is crucial to accurately predicting productivity.

Therefore, recalling that inexperienced firms understand the market's role less, (*i.e.* apply Assumption 2 to equation (5)) it follows that

Hypothesis 4 (Market Dynamism & Experience): *As market dynamism increases, the positive gap between forecast errors of less and more experienced firms increases.*

Similarly, since Eastern firms understand the market's role less than Western ones (*i.e.* applying Assumption 3 to equation (5)) it follows that

Hypothesis 5 (Market Dynamism & East): *As market dynamism increases, the positive gap between forecast errors of Eastern and Western firms increases.*

Markets differ not just in their dynamism but also in their predictability. The next fad in some markets is hard to guess, whereas the trends in others or obvious to all. In our data, the market signal is a composite opinion of market actors—when they agree, whether their common opinion is positive, negative or neutral, we say that the signal is precise (or alternatively the variance of the noise $\sigma_{\varepsilon\tau}^2$ is low); but when they disagree, whether the average opinion is positive, negative, or neutral, we say the signal is imprecise (or alternatively the variance of the noise $\sigma_{\varepsilon\tau}^2$ is high). We use the measured variance in the composite opinion of the future market state as a metric over market uncertainty.[3] Taking the derivative of equation (3) with respect to *historical* market signal variance (*i.e.* $\tau < t$)

$$\forall \tau < t, \frac{\partial MSE_{it}}{\partial \sigma_{\varepsilon\tau}^2} = \bar{y}_t^2 E\left[\frac{\partial b_{it}^2}{\partial \sigma_{\varepsilon\tau}^2}\right] > 0 \tag{6}$$

where the inequality follows from the fact that noisy market signals impedes learning the role of the market (Assumption 1). Thus,

Hypothesis 6 (Historical Market Uncertainty): *All firms make bigger forecast errors in historically uncertain markets.*

Lastly, we consider the evolution of forecast errors over time. Eventually, all firms will learn the role of the market for their productivity—the limit of the LHS of 4 as t grows large approaches 0 (from Assumption 2). Thus,

[3]Market signal uncertainty comes in two forms: (1) uncertainty about *previous* signals, and (2) uncertainty about the *current* signal. Only *historical variance* impacts the current understanding of the market's role, but *current variance* does not—a firm cannot use the current market signal to update its understanding of the markets role until after productivity has been realized at the end of the period. Therefore, we exclude current variance from consideration.

Hypothesis 7 (Convergence, Formal): *With sufficient experience, Eastern firms have approximately equal forecast errors as Western firms.*

Although we did not formally assume it, in most learning processes, one updates their beliefs more drastically (on average) based on early learning than on late learning. This is because, although each observation is (on average) as informative as all previous observations, the *relative* informativeness of early observations *at the time they are first observed* is higher simply because there are fewer previous observations when the information is first used to update beliefs. That is, typically, most of the adjustment to the original bias happens relatively early. Thus, although we argue it more loosely than our other hypotheses, we expect that

Hypotheses 8 (Convergence, Informal) *(i) The forecast error magnitudes of firms decrease quickly at first and more slowly later on. (ii) The forecast errors of Eastern firms decrease faster than those of Western firms.*

Above we establish a theoretical link between learning the role of the market and the *magnitude* of the overall productivity forecast error, which manifests predictably through estimated coefficients on the magnitude and variance of the market signal. Next, we establish a link between learning the role of the market and the *direction* of the overall productivity forecast error, which manifest through the sign of estimated coefficients on the directional market signal.

2.3 Forecast Error Direction

The expected (directional) forecast error in period t (ME_{it}, "mean error") from the perspective of an econometrician is written

$$ME_{it} = E_{c_i}\left[E\left[P_{it} - \hat{P}_{it}\middle|\, \hat{y}_t, c_i\right]\right] = \bar{y}_t E\left[b_{it}\right] \tag{7}$$

where we have followed steps analogous to those used to calculate equation (3) in order to simplify the solution. Taking the derivative of equation (7) with respect to the market signal

$$\frac{\partial ME_{it}}{\partial \hat{y}_t} = \frac{\partial \bar{y}_t}{\partial \hat{y}_t} E\left[b_{it}\right]$$

which has the sign of $E\left[b_{it}\right]$, since posterior beliefs of market state $\bar{y}_t$ are always updated in the direction of the signal $\hat{y}_t$ (*i.e.* $\frac{\partial \bar{y}_t}{\partial \hat{y}_t} > 0$ from equation (1)).

In a rational learning process, firms' best estimates of their market factors will be generally incorrect (*i.e.* $b_{it} \neq 0$) but, on average, unbiased (*i.e.* $E\left[b_{it}\right] = 0$). Thus, if learning were fully rational we would expect $ME_{it} = 0$. However, if a group of firms systematically underestimate the role of the market (*e.g.* $E\left[b_{it}\middle|\, i \in East\right] > 0$), then when market signals indicate improvement (*i.e.* $\hat{y}_t > 0$), the group's forecasts will be systematically pessimistic (*i.e.* underestimate future production: $ME_{it} > 0$), but when market signals indicated decline (*i.e.* $\hat{y}_t < 0$), the group's forecasts will be systematically optimistic (*i.e.* overestimate production: $ME_{it} < 0$). Precisely the opposite predictions hold if a group overestimates the role of the market.

Our fully rational learning model itself is agnostic about which direction, if any, the bias of East (or West) German firms might go. In fact, once one admits limits on rationality, one might expect the East could be biased in either direction relative to the West. Nevertheless, we conjecture that, under communism, market factors may have mattered less to firm productivity, and that East German

managers may not have correctly discounted their experience under that regime such that they, for a while, systematically underestimated the role of market forces on their firm's productivity (*i.e.* $E[b_{it}|\, i \in East] > 0$) relative to the managers of West German firms; however, since prior beliefs receive less and less weight in the posterior beliefs over time, the impacts of improper priors should diminish over time:

Hypothesis 9 (Old Habits Die Hard): *(i) When market signals indicate positive change, East German firms' forecasts are pessimistic (i.e. they underestimate actual productivity growth) relative to West German firms'. (ii) When market signals indicate negative change, East German firms' forecasts are optimistic (i.e. they actual overestimate productivity growth) relative to West German firms'. (iii) These effects diminish over time.*

Now, we map the hypotheses of our formal model to empirical specifications corresponding to the unique data set collected by the Ifo Institute.

3 Empirical Model

In this section we introduce two empirical models to test our hypotheses derived above. A first empirical model tests the hypotheses related to the error *magnitude*:

$$\begin{aligned} \text{SqErr}_{ijt} &= \alpha_{ij} + t_{tj} + \beta_{1j}\ \text{SqSig}_{ijt} + \beta_{2j}\ \text{HistVarSig}_{ijt} + \beta_{3j}\ \text{Exper}_{ijt} \\ &\quad + \beta_{4j}\ \text{SqSig}_{ijt} \times\ \text{Exper}_{ijt} + \beta_{5j}\text{Exper}^2_{ijt} \end{aligned} \tag{8}$$

where SqErr, the dependent variable is the square of $P_{it} - \hat{P}_{it}$ as in the theory section above. The variables are indexed by i for firm, j for region (East or West), and t for month. We estimate the equation separately for (i) the subsample of Western firms, (ii) the subsample of Eastern firms, and (iii) the entire sample where a dummy variable is set for Eastern firms. The separate subsample regressions (i) and (ii) facilitate the inclusion of firm fixed effects and exposition. Our dummied out version (iii) yields identical coefficients (and therefore we do not report the results separately) but is required to test whether coefficients for Western firms statistically differ from analogous coefficients for Eastern firms. SqSig is the square of the market signal (*i.e.* $\bar{y}_t^2$ from the theory). In our data, we observe the noise associated with each market signal (see next section); HistVarSig is a computed summary statistic (over time up to period t) for the historical variance of market signals. Exper is firm Experience, α is a firm fixed effect, and t is a time fixed effect. For estimation we add a classical error term ϵ.

The theory above makes the following predictions on error *magnitude*. Hypothesis 1 implies that β_{3j} the coefficient on Exper is negative. Hypothesis 2 implies that the average firm fixed effect in the East exceeds that in the West ($\bar{\alpha}_{East} > \bar{\alpha}_{West}$). Hypothesis 3 implies that a positive coefficient β_{1j} on SqSig. Hypothesis 4 implies that the coefficient β_{4j} on the interaction between SqSig and Exper is negative. And Hypothesis 5 suggests that the coefficient on SqSig in the East exceeds the coefficient on SqSig in the West ($\beta_{1East} > \beta_{1West}$). Though not formally derived, from Hypothesis 4 we expect that $\beta_{4East} < \beta_{4West}$, since being Western in our model is equivalent to adding additional experience with the free market. Hypothesis 8 implies a negative coefficient β_{3j} on Exper and a positive coefficient β_{5j} on the quadratic experience variable.

To test Hypothesis 9, on error direction, we use a slightly different empirical model:

$$\begin{aligned} \text{Err}_{ijt} &= \alpha_{ij} + t_{tj} + \delta_{1j}\ \text{Sig}_{ijt} + \delta_{2j}\ \text{Exper}_{ijt} \\ &\quad +\delta_{3j}\ \text{Sig}_{ijt} \times\ \text{Exper}_{ijt} + \delta_{4j}\text{Exper}^2_{ijt} \end{aligned} \tag{9}$$

The most significant difference between equations (8) and (9) is that the forecast error (the dependent variable) and the market signal are no longer in squares but in levels to preserve the directional information. Also, we drop the historical variance of the market signal, because our theory makes no straight forward prediction on the direction of its impact. The remaining setup is unchanged. Hypothesis 9 predicts that $\delta_{1East} > \delta_{1West}$. That is, when the market signal is positive the East (because of its improper weighting of experience under communism) predicts lower productivity relative to the West, thereby inducing a higher forecast error (production exceeds prediction more). On the other hand, when the market signal is negative the East predicts higher productivity relative to the West, inducing a lower forecast error (production falls shorter of prediction). Hypothesis 9 also suggests that over time the East and the West converge (to the same, potentially incorrect bias).

4 Data and Variables

Our data is from the Ifo Institute business climate survey, which, to our knowledge, is the oldest survey on firm expectations and realizations in existence. It started in November 1949 for the Federal Republic of Germany and included the former East Germany beginning in 1991. Our sample is for months from 1992 to 2010; we drop 1991 observations, because administrative difficulties render these earliest Eastern observations unreliable. The data is at the product level for about 12000 products. The data is for manufacturing firms only. Following Nerlove (1983, footnote 15) we treat product-level observations as independent; there are very few multi-product firms. Firms enter, exit and occasionally do not respond to the survey over our sample period. Thus, the panel is unbalanced. We drop all firms that report only once (forecast errors for such firms clearly cannot be computed). Like most surveys of this kind, the responses are granular, in our case trichotomous (*i.e.* '+', '=' or '-'). As the response categories are ordered we can compare forecasts and realizations to construct forecast errors. We use two survey questions about the quantity of domestic production. The forecast question reads:

> Expectations for the next three months: Our domestic production activities with respect to product X will (without taking into account differences in the length of months or seasonal fluctuations) increase, roughly stay the same, decrease.

And the question about the realization reads:

> Trends in the last month: Our domestic production activities with respect to product X have (without taking into account differences in the length of months or seasonal fluctuations) increased, roughly stayed the same, decreased.

A mismatch between the time horizons of the two questions complicates forecast error calculation:

Table 1: Error Calculation

Realized	Forecast	Error
+1	+1	0
+1	0	+1
+1	-1	+2
0	+1	-1
0	0	0
0	-1	+1
-1	+1	-2
-1	0	-1
-1	-1	0

1. First, we calculate a realized productivity measure equal to the majority of actual productivity responses in the three months following the forecast, but drop the observation if there is a 'contradiction.' We do not distinguish three increases from two increases or (net) one increase, because the survey respondent could not make such a distinction in prediction. For example, if a firm reports 'increased,' 'stayed the same,' and 'increased' in months $t+1$, $t+2$ and $t+3$ respectively, we compute a realized productivity associated with the forecast in period t as 'increased' (literally +1). On the other hand, if the firm had reported 'decreased' in period $t+2$ instead, we would have dropped the observation. If a firm does not report in one or two of the periods following the forecast complete the same calculation with the remaining survey responses. Our error calculation of realized productivity mirrors Nerlove (1983).

2. Second, we calculate a forecast error according to Table 1 where, for example, an error of '-1' indicates that the firm was optimistic (*i.e.* produced less than forecast), while and error of '-2' indicates the firm was not just optimistic, but forecast was in the opposite direction of the realization (*i.e.* expected increase but experienced decrease).

As a proxy for the market signal $\hat{y}_t$ we take the month-on-month change average response (by product group) to following survey question:

> Expectations for the next six months: The business environment for product X will, from a business cycle perspective, improve, stay the same, or worsen.

The Ifo Institute aggregates the responses to this question, weighted by respondents' number of employees, and widely publishes the results as the "Ifo Business Climate Index," which is regularly discussed in the news and is generally regarded as an indicator of the market's overall health. As a participation incentive, Ifo releases to survey respondents the aggregate numbers for their own product

Table 2: Summary statistics

	West				East			
	mean	*sd*	*max*	*min*	*mean*	*sd*	*max*	*min*
Forecast Error	−0.0483	0.582	2.00	−2.00	−0.0836	0.628	2.00	−2.00
Experience	7.0434	5.172	19.17	0.08	6.0593	4.898	19.17	0.08
Market Signal	−0.0010	0.063	0.50	−0.50	0.0045	0.090	0.50	−0.50
Hist. Signal variance	0.0093	0.019	0.50	0.00	0.0181	0.032	0.50	0.00
Observations	493627				95785			

group—in other words, Ifo explicitly compiles and sends a formal market signal to survey respondents on a monthly basis. Thus, we use the product level aggregate, weighted by the respondents' number of employees as our market signal.

Since we observe the individual opinions the market actors, we can also observe the level of their agreement, tantamount to the amount of noise in the market signal. Thus, we compute the HistVarSig_{ijt} as the mean over all past variances of the responses to the above survey question *(i.e.* we summarize the set $\{\sigma^2_{\varepsilon 1}, ..., \sigma^2_{\varepsilon t-1}\}$ as $\text{HistVarSig}_{ijt} = \frac{1}{t-1}\sum_{\tau=1}^{t-1}\sigma^2_{\varepsilon\tau}$).

Table 2 provides summary statistics. Observe that the mean forecast error (in both East and West) is negative—firms are optimistically biased. This phenomenon, as discussed in the introduction, has been observed in the psychological literature at the individual level. Also, we see that the mean unconditional forecast error is lower in the East; though this difference is statistically insignificant—firms may be more optimistic in the East during our sample period. About 20 per cent of observations are Eastern. We calculate firm experience at time t as$t$ minus the date of the first survey response by firm i in our sample, which begins in January 1992. Thus, experience in our sample does not differ significantly by region. Overall, Western and Eastern firms do not differ greatly in the variables of interest.

5 Results

This section presents our regression results. Our dependent variable, the forecast error or its square, is categorical, because it is derived from categorical survey responses. We use a linear probability model, which allows for the straightforward inclusion of firm and time fixed effects and facilitates interpretation of interaction terms. Since all our of hypotheses are qualitative we are mostly interested in the signs rather than magnitudes of the estimated coefficients. Thus, the linear probability model is appropriate.

Table 3 presents a set of regressions that test the hypotheses on forecast error *magnitude*; that is, the dependent variable is the square of the forecast error. Squared errors have values 0 (no error), 1 (low error), or 4 (high error). In the table we only present the results for the sub-sample regressions; we report the statistical difference between Eastern and Western coefficients in the text. Column (1) and (2) in Table 3 give estimates for models omitting firm and month fixed effects. Columns (3)

and (4) give models that include firm fixed effects. And columns (5) and (6) give models that also include month fixed effects—this specification, which controls for many factors unobservable in our data, conveys our main results. In the remainder of the section we only use these specifications to explicitly test our hypotheses.

The negative coefficients on $Exper$ for both East and West support Hypothesis 1, namely, less experienced firms have a higher probability of making a higher forecast error. This is different than *forecasts improve over time*, something which could occur simply due to negative selection—less effective forecasters may be more likely to exit. On the contrary, this result shows that learning occurs at the firm level.

Hypothesis 8 predicts (i) a positive coefficient on $Exper^2$, which we find—the gains from experience are diminishing. Hypothesis 8 also predicts that (ii) the coefficient on $Exper$ in the East is less than the coefficient on $Exper$ in the West, which we also find. The difference is statistically significant at a 1 per cent level. This is consistent with the view that the East joined the market economy with less understanding of the role of the market but caught up the West (who already understood it).

Comparing the constants between East and West, the average forecast error is higher in the East, supporting Hypothesis 2—Eastern firms understand the market less well.

The positive coefficients on $SqSig$ support Hypothesis 3, which says that more dynamic markets lead to higher forecast errors in both the East and West. Hypothesis 5 predicts that the coefficient on $SqSig$ in the East exceeds the coefficient on $SqSig$ in the West, which it does, and the difference is statistically significant at a 2.3 per cent level. Moreover, the negative coefficients on the interaction between $SqSig$ and $Exper$ support Hypothesis 4: dynamic markets harm the forecasts of the inexperienced more. Intuitively, understanding of the market's role for productivity change is most critical when the market environment is expected to change. Thus, inexperienced firms, especially Eastern ones, are disadvantaged in dynamic markets.

Finally, the positive coefficients on $HistVarSig$ suggest that learning in more uncertain environments is more difficult, in support of Hypothesis 6.

Table 3: Test of Hypotheses on Error Magnitude

	(1) West	(2) East	(3) West	(4) East	(5) West	(6) East
SqSig	0.3570^{***}	0.4797^{***}	0.4442^{***}	0.7502^{***}	0.3972^{***}	0.7735^{***}
	[0.097]	[0.132]	[0.101]	[0.142]	[0.101]	[0.142]
HistVarSig	-0.1367^{*}	0.2313^{**}	0.1067	0.3927^{*}	0.0749	0.4342^{*}
	[0.054]	[0.079]	[0.130]	[0.185]	[0.130]	[0.185]
Exper	-0.0028^{***}	-0.0232^{***}	0.0003	-0.0161^{***}	-0.0045^{**}	-0.0187^{***}
	[0.001]	[0.002]	[0.001]	[0.002]	[0.001]	[0.003]
SqSig × Exper	−0.0063	0.0068	−0.0107	-0.0316^{*}	−0.0098	-0.0354^{*}
	[0.009]	[0.014]	[0.009]	[0.015]	[0.009]	[0.015]
Exper^2	0.0000	0.0010^{***}	−0.0000	0.0007^{***}	0.0003^{***}	0.0005^{***}
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.3577^{***}	0.4711^{***}	0.3384^{***}	0.4439^{***}	0.2987^{***}	0.4393^{***}
	[0.002]	[0.005]	[0.002]	[0.007]	[0.010]	[0.031]
Firm Fixed Effects	*No*	*No*	*Yes*	*Yes*	*Yes*	*Yes*
Month Fixed Effects	*No*	*No*	*No*	*No*	*Yes*	*Yes*
Observations	493627	95785	493627	95785	493627	95785

Standard errors in brackets

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Evidence in support of Hypothesis 7 is presented in Figure 3. Figure 3 plots the *predicted* forecast errors for Eastern and Western firms using the respective coefficients from models (5) and (6) in Table 3. Predicted values for the two regions coincide after 12 years of experience. An alternative way of estimating the time for East and West to converge is to consider when coefficients for East and West no longer statistically differ. Both theoretically and empirically, the coefficient on market signal best represents the difference between the East's and West's understanding of the market's role on productivity. Therefore, we consider when the coefficients on market signal for East and West cease to differ statistically for sub-samples including only data after various threshold years. The p-values on the difference for thresholds 2000 to 2006 are as follows: 0.008 (2000-2010), 0.036 (2001-2010), 0.182 (2002-2010), 0.242 (2003-2010), 0.079 (2004-2010), 0.729 (2005-2010), 0.542 (2006-2010). The coefficients are not statistically different at a five percent level for any sub-sample after 2002. This result is similar to the convergence for the predicted forecast errors. That is, Eastern firms that existed at Reunification had 11 years of experience by 2002 and after that time, the differences between Eastern and Western responses to market signals were statistically indistinct. Thus, we find significant empirical for all eight of our hypotheses relating learning the role of the market to forecast error magnitude.

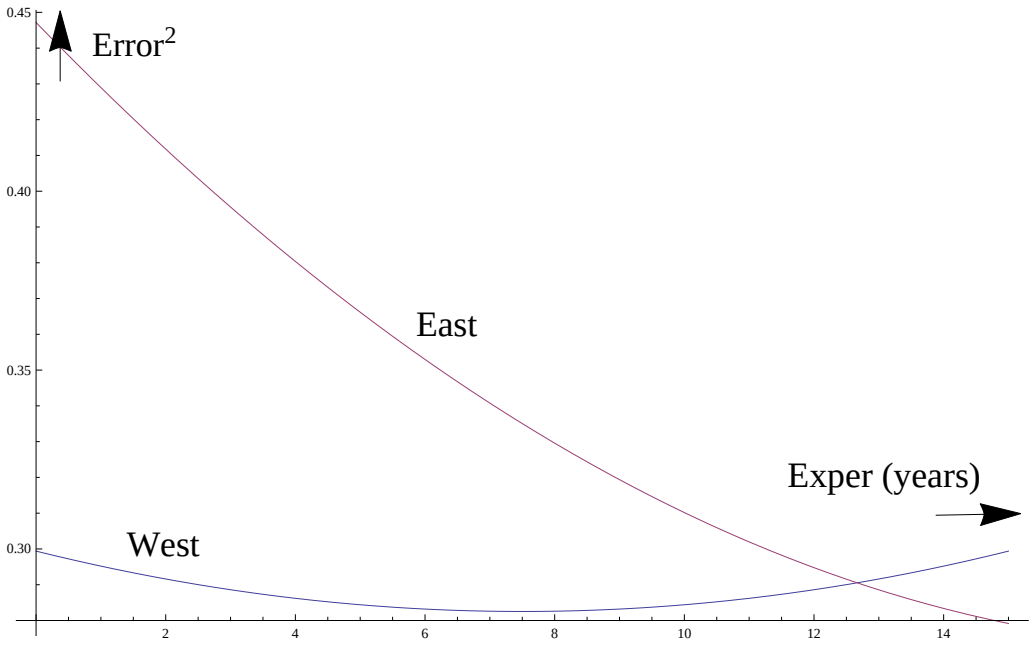

Figure 3: These graphs plot the predicted values for the error magnitude over experience.

Now we turn to the results for the directional forecast error in Table 4. Here the forecast error and the market signal are in levels and not squares, *i.e.* the forecast errors reflects systematic biases rather than imprecision, and the market signal captures growth and contraction rather than just dynamism. Again, columns (1) and (2), omit fixed effects, columns (3) and (4) add firm fixed effects and columns (5) and (6) add month fixed effects also. Hypothesis 9 predicts (i) that the coefficient on Sig in the East exceeds the coefficient on Sig in the West and (ii) that the level of the forecasts errors in East

and West converge on to a common bias. We find support in both parts of the Hypothesis. First, the coefficient on *Sig* is significantly larger (at less than the five percent level) in the East implying that firms in the East underestimate the potency of the market for their productivity *relative* to the West.

Interestingly, and beyond the predictions of our model, firms in *both* regions overestimate the importance of the market for their productivity. Also, and again outside our model, the East's constant indicates that the East was more generally optimistic immediately following Reunification (possibly due to euphoria from the regime change), but the positive sign on *Exper* (relative to the West) indicates convergence. We also look at convergence in terms of the statistical difference of the *Sig* coefficient for East and West. As above, for the years 2000 to the end of the sample through 2006 to the end of the sample the p-values of a difference test are: 0.008 (2000-2010), 0.007 (2001-2010), 0.033 (2002-2010), 0.228 (2003-2010), 0.682 (2004-2010), 0.608 (2005-2010), 0.792 (2006-2010). The values exceed a five percent significance threshold in 2003. Again convergence in biases occurs at about the about the same time as convergence for forecast error magnitude above. To summarize, we also find empirical evidence that the East improperly weighted their prior experience under communism, such that they underestimated the role of the market for their productivity *relative* to the West, but over about 14 years converged to the same irrational overestimation of the market's importance as the West.

Table 4: Test of Hypotheses on Error Direction

	(1) West	(2) East	(3) West	(4) East	(5) West	(6) East
Sig	-0.4674^{***}	-0.3329^{***}	-0.4416^{***}	-0.2965^{***}	-0.4473^{***}	-0.2870^{***}
	[0.020]	[0.019]	[0.021]	[0.021]	[0.022]	[0.021]
Exper	-0.0040^{***}	0.0127^{***}	-0.0055^{***}	0.0066^{***}	-0.0021	0.0207^{***}
	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]	[0.003]
Sig × Exper	0.0141^{***}	0.0094^{***}	0.0153^{***}	0.0077^{**}	0.0126^{***}	0.0055^{*}
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Exper^2	0.0002^{***}	-0.0006^{***}	0.0002^{***}	-0.0003^{**}	-0.0000	-0.0003^{**}
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	-0.0386^{***}	-0.1253^{***}	-0.0293^{***}	-0.1053^{***}	-0.0403^{***}	-0.1675^{***}
	[0.002]	[0.004]	[0.002]	[0.005]	[0.009]	[0.026]
Firm Fixed Effects	No	No	Yes	Yes	Yes	Yes
Month Fixed Effects	No	No	No	No	Yes	Yes
Observations	502615	103148	502615	103148	502615	103148

Standard errors in brackets

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6 Conclusion

First, we have shown that the productivity forecasts of firms located in former East Germany were significantly less accurate for at least a decade following the end of communism. This can be explained, in the context of a learning model, by their limited experience with a market economy—they had to learn the role of the market for their firms over time, through experience. The model makes nine distinct predictions, which taken together rule many alternative explanations. Among these the model predicts that firms inexperienced in the market, especially Eastern ones, estimate future productivity particularly poorly in dynamic and historically uncertain markets. Our empirical analysis confirms all nine the model's direct predictions.

Second, we conclude from our results that firms do not form expectations rationally. If they did, neither the East's nor the West's predictions would exhibit systematic bias. While our learning model cannot explain the long-term levels of optimistic bias that both East and West converge to, we confirm the existence of this firm level bias consistent with similar biases that have been long confirmed by psychologists at the individual level.

However, our learning model does offer an explanation for some of the *difference* in bias that existed between Eastern and Western firms in early years. Although the East seemed to experience a baseline euphoria in making production predictions in the early years after Reunification—their forecasts were simply too high—the East also systematically appeared to underestimate the *role of the market* r*elative* to the West in these years. This manifested in that when market signals indicated good times ahead, Eastern errors (*i.e.* actual production minus forecast production) were relatively higher than Western ones, and when markets signaled bad times ahead, Eastern errors were relatively lower than Western ones. This behavior is consistent with the view that the East overweighted their experience under communism, where the market played little role, when making forecasts in the new market economy.

However, both the East's production forecast inaccuracy and bias converged to Western levels in time. Nevertheless these differences in production forecast accuracy remained statistically significant for at least 11 to 13 years after Reunification, a longer time than many might have predicted.

Our findings temper one's expectations for the transitions to free-market economies currently underway in China and India, the recent wave of revolutions known as the "Arab Spring," or the hypothetical introduction of democratic and capitalistic institutions in other lands, like North Korea. While structural changes may occur quite quickly, our ability to adjust our priors to those suited to the new environment can take much longer.

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