An Explanation for the Joint Evolution of Firm and Aggregate Volatility*

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Abstract

The US economy has become more stable. At the same time, US firms have become more volatile. I present the evidence and I propose a common explanation, based on the idea that goods markets have become more competitive. Competition between firms magnifies the effects of idiosyncratic productivity shocks: This can explain the rise in firm volatility. On the other hand, for given nominal adjustment costs, competitive pressures will induce firms to increase the frequency of their price adjustments. As a result, the economy will be more resilient to aggregate demand shocks. My calibration suggests that competitive pressures may have reduced the impact of demand shocks by 40%.

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The decline in aggregate volatility was first described by Kim and Nelson (1999) and McConnell and Perez-Quiros (2000). Both papers conclude that the decline happened in the first quarter of 1984. Blanchard and Simon (2001) interpret the same data as a downward trend in the post-war period, interrupted by a period of high instability in the 1970s. Stock and Watson (2002) examine the quantitative importance of various explanations for the increased stability of the economy, and reach mixed conclusions: "Taken together, we estimate that the moderation in volatility is attributable to a combination of improved policy (20-30%), identifiable good luck in the form of productivity and commodity price shocks (20-30%), and other unknown forms of good luck that manifest themselves as smaller reduced form forecast errors (40-60%)."

I propose an explanation for these "unknown forms of good luck." I argue that the US economy has become structurally more stable because goods markets have become more competitive. This explanation is appealing because the decline in aggregate volatility coincided with a large increase in volatility at the firm level, as I show below[1]. Competition increases the volatility of firms because it magnifies the effects of idiosyncratic productivity shocks. I study the implications of this hypothesis in a standard macroeconomic model with nominal rigidities. Since it is costly to set the wrong price in a competitive environment, firms will increase the frequency of their price adjustments when competition increases. As a result, the effects of nominal spending shocks will be smaller and shorter-lived.

The decline in aggregate volatility is, by now, a well-known fact. The increase in firm volatility is less well known. It was first pointed out in Campbell, Lettau, Malkiel, and Xu (2001) for stock returns, and in Chaney, Gabaix, and Philippon (2002) and Comin and Mulani (2003) for real variables (sales, employment, investment..). Campbell, Lettau, Malkiel, and Xu (2001) show that the volatility of individual stocks was multiplied by more than two between the 1960s and the 1990s. The increase in firm volatility is interesting because it can help us discriminate among competing explanations for the decrease in aggregate volatility. On the other hand, one can wonder why the two phenomenons ought to be related: after all, these are just two trends that happen to go in different directions. There seems to be a deeper connection however, both across industries in the US, and across countries.

[1] For evidence that the integration of product and financial markets has rendered modern economies more competitive, see Blanchard and Philippon (2002) and the references therein.

Chaney, Gabaix, and Philippon (2002) show that, controlling for past volatility (pre-1984), the current (post-1984) volatility of an industry is negatively related to the increase in firm volatility within this industry. Hamao, Mei, and Xu (2003) report that, contrary to the US, idiosyncratic risk has been falling in Japan in the 1990's, precisely at the time when aggregate risk was increasing[2].

I present the empirical evidence in section 1. In section 2, I introduce a simple model of firm and aggregate volatility. I propose a calibration in section 3 and I conclude by discussing the predictions of the model as well as some alternative explanations.

1 Evidence

Figure 1 shows that the US economy has become more stable while US firms have become more volatile. Aggregate volatility is the standard deviation of the annual log-growth rate of real GDP, using quarterly data. Similarly, firm volatility is the standard deviation of $\log(sales_t) - \log(sales_{t-4})$. I measure firm volatility using COMPUSTAT over the period 1965-2001. The composition of the sample changed over this period: Firms in the recent part of the sample are on average younger, and operate in different sectors of activity, than firms in the early part of the sample. The results presented in figure 1 are conditional on age and sectorial composition: In other words, I compare the volatility of a 10 years old firm in retail trade during the period 1990-1995 to the volatility of a 10 years old firm in retail trade during the period 1970-1975. Between the first half and the second half of the sample period (1965-1980 versus 1986-2001), aggregate volatility went down from 2.6% to 1.5%, while firm volatility went up from 14% to 25%.

To construct these estimates, I start from the complete COMPUSTAT sample. I drop firms for which I do not have at least 20 quarterly observations. I subtract the median growth rate in each quarter to control for variations in sales growth common to all firms (aggregate shocks)[3]. I then compute the volatility of each firm within each window of 5 years. Finally, I run

$$volat_{ij\tau} = \alpha_j + \beta_{age_{i,\tau}} + \gamma_\tau$$

[2] More generally, Morck, Yeung, and Yu (2000) show that idiosyncratic risk relative to aggregate risk is much larger in rich countries than in developing countries.

[3] I also winsorize the log growth rates of sales at 5% and 95% within each quarter to remove the influence of outliers.

where i is firm, j is sector and $\tau = 65 - 70, 71 - 75$.. Figure 1 shows the time dummies γ_τ plus the average volatility in the initial period. The results of the regression are in Table 1. I also made some robustness checks. The results do not change if I control for firm size (measured by deflated total assets) instead of firm age, or if I run median regressions instead of OLS.

2 A model of firm and aggregate volatility

The purpose of this section is to show how the textbook business cycle model with nominal rigidities can be used to study the effects of competition of firm and aggregate volatility. In doing so, I make only the required modifications: First, I introduce idiosyncratic shocks, and second, I let the firms choose the frequency of price adjustments endogenously. The benefit of this approach is its parsimony. The cost is that the resulting model will have the same well-known problems as the benchmark one (see Woodford (2003) and Bils and Klenow (2002)), and one should keep in mind this caveat when interpreting the quantitative results.

Consider an economy populated by a continuum of consumers-workers, who maximize:

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(U \left(C_t, \frac{M_t}{P_t} \right) - \frac{\phi}{1+\phi} L_t^{\frac{1+\phi}{\phi}} \right) \right]$$

subject to

$$C_t + \frac{M_t}{P_t} + B_t \leq \Pi_t + W_t L_t + \frac{M_{t-1}}{P_t} + (1 + R_t) B_{t-1}$$

Consumers receive labor income $W_t L_t$, the aggregate profits of the firms Π_t and the interest payments R_t on their real bond holdings B_t. They hold real money balances $\frac{M_t}{P_t}$. The real bond is in zero net supply and all aggregate uncertainty comes from the nominal money supply, which is random and exogenous. M_t needs not be interpreted as a monetary shock: For instance, shocks to consumers' impatience to consume would enter the aggregate demand equation in similar way, as we will see below in equation (3) (see Woodford (2003) for a discussion). For simplicity, I shall continue to refer to M_t as the money supply shock.

The only non-standard feature of this model is the presence of idiosyncratic productivity (taste) shocks.

$$C_t = \left(\int_0^1 \tilde{C}_{i,t}^{\frac{\theta-1}{\theta}} di\right)^{\frac{\theta}{\theta-1}} ; \tilde{C}_{it} = Z_{it} \times C_{it}$$
$$P_t = \left(\int_0^1 \left(\frac{P_{it}}{Z_{it}}\right)^{1-\theta} di\right)^{\frac{1}{1-\theta}} ; \int_0^1 Z_{it}^{\theta-1} di = 1$$

The consumption of C_{it} physical units of good i delivers the same utility as the consumption of $\frac{Z_{it}C_{it}}{Z_{jt}}$ units of good j. The processes Z_{it} are exogenous, and conveniently normalized.

Goods markets operate under monopolistic competition, labor is the only factor of production and its marginal productivity (in physical units) is constant and normalized to 1. Cash flows are $\pi_{it} = \left(\frac{P_{it}}{P_t} - W_t\right) Y_{it}$ and the stochastic discount factor is $\beta^{t'-t}\Psi_{t,t'}$. The objective of the firm is therefore to maximize:

$$V_{it} = E_t^i \left[\sum_{t'=t}^{\infty} \beta^{t'-t}\Psi_{t,t'} \times \pi_{it'}\right]$$

subject to the demand curve

$$Y_{it} = C_t \times Z_{it}^{\theta-1} \times \left(\frac{P_{it}}{P_t}\right)^{-\theta}$$

I assume, as in Calvo (1983), that firms have a probability $(1-\lambda)$ to reset their price in any given period. Let Q_{it} be the price chosen by firm i at time t if it gets the chance to reset its price. The FOC yields:

$$Q_{it} = \frac{\theta}{\theta-1} \frac{\sum_{t'=t}^{\infty} E_t^i \left[Z_{it'}^{\theta-1}\right] (\beta\lambda)^{t'-t} \times E_t\left[\Psi_{t,t'} P_{t'}^{\theta} W_{t'}\right]}{\sum_{t'=t}^{\infty} E_t^i \left[Z_{it'}^{\theta-1}\right] (\beta\lambda)^{t'-t} \times E_t\left[\Psi_{t,t'} P_{t'}^{\theta-1}\right]} \tag{1}$$

To derive this formula, I have used the independence of idiosyncratic and aggregate shocks. Equation (1) shows that idiosyncratic shocks introduce a firm specific discount factor. In particular, if Z_{it} is mean reverting, the implied discounting is not geometric and firms with different shocks at time t will set different prices. I assume that the idiosyncratic shocks follow the process

$$\log(Z_{it}) = \rho_z \log(Z_{it}) + \nu_{it+1}$$

where ν is *iid* and normally distributed $N(0, \sigma_z)$. In this case,

$$E_t\left[Z_{t+j}^{\theta-1}\right] = \left(Z_t^{\theta-1}\right)^{\rho^j} \times E_t \exp\left((\theta-1)\sum_{s=0}^{j-1} \rho_z^s \eta_{t+j-s}\right)$$

However, it turns out that, in the data, the process Z has a unit root: $\rho_z \approx 1$[4]. This simplifies a lot the algebra, since it implies that

$$E_t\left[Z_{t'}^{\theta-1}\right] = Z_t^{\theta-1} \times \delta^{t'-t}$$

where

$$\delta = \exp\left(\frac{(\theta-1)^2 \sigma_z^2}{2}\right)$$

I therefore obtain a simple generalization of the usual formula. Using lower cases to denote log deviations from steady state, the price setting equation is:

$$\frac{q_t}{1-\beta\lambda\delta} = E_t\left[\sum_{t'=t}^{\infty} (\beta\lambda\delta)^{t'-t} (w_{t'} + p_{t'})\right] \tag{2}$$

Note that, despite the idiosyncratic shocks, all the firms still choose to set the same price, and the price level evolves according to:

$$p_t = \lambda p_{t-1} + (1-\lambda) q_t$$

Technology and labor supply decisions imply that $w_t = \left(\frac{1}{\phi} + \frac{1}{\sigma}\right) y_t$, where σ is the elasticity of intertemporal substitution. I consider the limit economy described in Woodford (2003), where real balances amount to a small fraction of GDP, and I obtain for the demand side of the economy:

$$\begin{aligned} m_t - p_t &= \eta_y y_t - \eta_i i_t \\ y_t &= E_t[y_{t+1}] - \sigma(i_t - E_t[p_{t+1} - p_t]) \end{aligned}$$

I have introduced the usual parameters: η_i is the semi-elasticity of money demand with respect to the interest rate, η_y is the income elasticity of money demand and σ is the elasticity of intertemporal substitution. I combine these two equations into:

$$E_t\left[\sigma p_{t+1} + y_{t+1} - \left(\sigma + \frac{\sigma}{\eta_i}\right) p_t - \left(1 + \frac{\sigma\eta_y}{\eta_i}\right) y_t + \frac{\sigma}{\eta_i} m_t\right] = 0 \tag{3}$$

[4] This suggests that the distribution of Z in steady state should have an infinite variance. Empirically, mean reversion is entirely due to the life cycle of firms: young firms tend to have positively auto-correlated growth rate ($\rho > 1$) while old firms have negatively correlated growth rates. In any case, both young and old are very close to following random walks over the short run.

As noted above, the disturbance term $\frac{\sigma}{\eta_i}m_t$ in equation (3) needs not be interpreted as a monetary shock: Shocks to consumers' impatience to consume would enter the aggregate demand equation in a similar way. I assume that m_t follows an $AR(2)$ process with persistence $\rho = (\rho_1, \rho_2)$ and normally distributed shocks ε_t with variance σ_ϵ^2:

$$m_t = \rho_1 m_{t-1} + \rho_2 m_{t-2} + \varepsilon_t$$

Figure 2 shows the impulse response of the economy to a persistent shock $\rho = (1.58, -0.724)$[5]. The price level initially increases less than one for one with the nominal shock, so that both real balances and real output increase. Over time, the shock disappears and prices adjust.

As is well known, the (real) volatility of this economy increases with λ. When $\lambda = 0$, the volatility is also 0. When $\lambda = 1$, prices are fixed and y_t moves with (m_t, m_{t-1}). I assume that firms choose λ optimally to maximize profits net of nominal adjustment costs:

$$E\left[V_i(\lambda_i) \mid \lambda, \rho, \sigma_\varepsilon, \delta, \theta\right] - (1 - \lambda_i) \times \frac{\digamma}{1-\beta}$$

Each price change costs $\digamma$. Note that E denotes expectations over the ergodic distribution of firm and aggregate variables: Firms choose λ knowing in which economy they are going to operate but before the realization of any shock[6]. Using a second order approximation, one finds that profit losses due to lack of price adjustment are given by

$$\frac{\theta - 1}{2}\left(p_{it} - p_t - w_t\right)^2$$

Competition (θ) increases the curvature of the profit function and, therefore, the cost of deviating from the optimal price. The loss function $\Lambda(\lambda, x\,; \rho, \sigma_\varepsilon, \delta) = E\left[(p_i - p - w)^2 \mid \lambda, \rho, \delta, \sigma_\varepsilon, \lambda_i = x\right]$ plays a crucial role in the model. $\frac{\partial \Lambda}{\partial x}$ measures the marginal loss from an increase in nominal rigidity. Figure 3 shows the shape of the function $\Lambda(\lambda, x)$ for calibrated values of $(\delta, \rho, \sigma_\varepsilon)$: Losses from lack of price adjustment are convex and increasing in x, and increasing in λ. It is not a-priori obvious whether $\Lambda(\lambda, x)$ should be increasing or decreasing in λ. When λ decreases, w becomes less volatile (real volatility decreases), while p becomes more volatile (nominal volatility increases): The net effect is, in general, ambiguous. In fact, it depends

[5] These values are estimated using the historical series of detrended GDP, as explained below.

[6] This is the conceptually correct way to think about the choice of λ. It is better than to assume that the economy start in the non-stochastic steady state ($p_0 = 0$) and to compute the NPV of profit losses. Here, I assume that the economy starts in the stochastic steady state, i.e. the state variables of the first period are drawn from the ergodic distribution.

on the real rigidity of the economy. When $\lambda = 0$, $w \equiv 0$ and $p \equiv m$, the volatility of $p + w$ is equal to the volatility of m. When $\lambda = 1$, we see that $w \equiv \frac{1+\phi}{\phi} y$ and $p \equiv 0$. Whether the volatility of the nominal marginal cost is higher or lower when $\lambda = 1$ than when $\lambda = 0$ depends, among other things, on the elasticity of labor supply.

The final step is to find the equilibrium choice of λ. Since λ_i is chosen non cooperatively, I define:

$$\tilde{\lambda}\left(\lambda, \delta, \rho, \sigma_{\varepsilon}, \theta, F\right) = \arg\min_{x} \left\{ \Lambda\left(\lambda, x\,; \rho, \sigma_{\varepsilon}, \delta\right) + (1 - x) \times \frac{2}{\theta - 1} F \right\} \tag{4}$$

A particular λ is a Nash equilibrium if and only if:

$$\tilde{\lambda}\left(\lambda, \delta, \rho, \sigma_{\varepsilon}, \theta, F\right) = \lambda$$

This gives us $\lambda\left(\rho, \delta, \sigma_{\varepsilon}, \theta, F\right)$. If if were not for δ, it would be obvious from equation (4) that $\frac{\partial \tilde{\lambda}}{\partial \theta} < 0$. The issue is that δ depends on θ and that Λ depends on δ in a complicated way. In my benchmark calibration however, I find that δ is always very close to 1 and that changes in θ have a very small impact on aggregate dynamics conditional on λ. As long as $\frac{\partial \tilde{\lambda}}{\partial \lambda} < 1$, we will also have $\frac{\partial \lambda}{\partial \theta} < 0$[7], and an increase in competition in the goods market will lead to a decrease in price stickiness and real aggregate volatility. I now turn to the quantitative investigation of this mechanism.

3 Calibration

The idea behind the calibration is simple. I start from an economy with low competitive pressures ($\theta = \theta_0$) and I calibrate the idiosyncratic shocks Z_{it} to match the empirical volatility of firms' sales before 1980. Keeping everything else constant, I increase θ to $\bar{\theta}$ by exactly the amount necessary to explain the increase in volatility at the firm level. I then compute the new equilibrium, in particular the new parameter $\lambda\left(\rho, \sigma_{\varepsilon}, F, \bar{\theta}\right)$, and I compare the volatility of the new economy to the volatility of the old economy.

The baseline parameters of the model are $\phi = 4$ for the elasticity of labor supply and $\sigma = 1$ for the elasticity of intertemporal substitution (as in the RBC literature), $\theta_0 = 4$ as in Rotemberg and Woodford (1999), and $\lambda_0 = .75$ implying that prices are changed on average once a year. I choose the demand shock to explain the historical time series of HP-filtered

[7] In particular, this will be true as long as the economy does not have multiple equilibria.

real GDP: Given the values of (ϕ, λ_0), I solve for ρ and m_t such that the model implies the correct path of detrended GDP over the post-war period, and the persistence of the money shock assumed by the agents when making their forecasts is the same as in the data[8].

The real sales of firm i at time t are given by

$$y_{it} + p_{it} - p_t = c_t + (\theta - 1) z_{it} - (\theta - 1)(p_{it} - p_t)$$

I calibrate the volatility of z_{it} to match the volatility of firms in the first half of the sample, given the initial value for θ. Note that this is not completely straightforward since aggregate and firm dynamics are jointly determined: δ depends on the volatility of z while the predicted volatility of sales depends on all the aggregate dynamics through the volatility of $p_{it} - p_t$. I calibrate $\sigma_z = 4\%$ to fit an initial firm volatility of 14%. I now have all the parameters of the economy plus a series of aggregate shocks m_t.

ρ	σ_ε	η_i	η_y	θ_0	ϕ	σ	λ_0	σ_z
$(1.58, -0.724)$	0.86%	1	1	4	4	1	.75	4%

I then choose the nominal adjustment costs to be consistent with my calibration of the old economy: F is such that $\lambda(\rho, \sigma_\varepsilon, \delta_{\theta_0}, F, \theta_0) = .75$. To invert this formula, I need to simulate the mapping $\Lambda(\lambda, x)$ defined above and shown in figure 3. To match the increase in sales growth volatility from 14% to 25%, I estimate $\bar{\theta}$ to be 5.7. The Nash equilibrium choices are given by[9]:

$$\begin{aligned} \tilde{\lambda}(\lambda_0, \delta_{\theta_0}, \rho, \sigma_\varepsilon, \theta_0, F) &= \lambda_0 \\ \tilde{\lambda}\left(\bar{\lambda}, \delta_{\bar{\theta}}, \rho, \sigma_\varepsilon, \bar{\theta}, F\right) &= \bar{\lambda} \end{aligned}$$

Figure 4 shows graphically how the Nash equilibria are computed. The top line represents $\tilde{\lambda}(\lambda, \rho, \sigma_\varepsilon, \delta_{\theta_0}, F, \theta_0)$ as a function of λ, while the lower line plots the same function when

[8] This amounts to looking for a fixed point. Make a guess for the persistence of the shocks, say $\rho^0 = [\rho_1^0, \rho_2^0]$. Given this guess and the other parameters (ϕ, λ, θ), solve the model with rational expectation. The solution for output is

$$\begin{aligned} y_t &= \alpha_y(\rho^0) p_{t-1} + \gamma_y(\rho^0) . [m_t, m_{t-1}] \\ p_t &= \alpha_p(\rho^0) p_{t-1} + \gamma_p(\rho^0) . [m_t, m_{t-1}] \end{aligned}$$

One can invert these equations and solve for m_t as a function of $\{y_{t-i}\}_{i \geq 0}$. In general, the persistence $\hat{\rho}^0$ of the implied series of m_t is not equal to ρ^0. Start over using $\rho^1 = \hat{\rho}^0$ until convergence. See King and Rebelo (1999).

[9] Recall that δ depends on θ (holding σ_z constant). In practice, this does not matter much since $\delta_{\theta_0} = 1.0072$ and $\delta_{\bar{\theta}} = 1.0177$.

$\theta = \bar{\theta}$. I estimate $\bar{\lambda} = .585$. The dynamics of the high competition economy are compared with the ones of the low competition economy in figure 5 (for GDP) and 6 (for prices). The volatility of real GDP is 40% lower in the competitive economy. The model also predict a drop in inflation persistence, from 0.7 to 0.65.

4 Discussion and Conclusion

My calibration suggests that competitive pressures in the goods market may have reduced the impact of demand[10] shocks[11] on the economy by 40%.

The model predicts an increase in the frequency of price adjustments and a decrease in the persistence of inflation. I estimated a new value of λ of .585 if the true value before 1980 was .75: this would imply an average duration of 7.2 months in the mid-1990s. Bils and Klenow (2002) report a dramatic decrease in inflation persistence, from 0.63 when estimated over the long sample (1959 to 2000, Table 6) down to 0.2 during 1995-2000. The model makes the right qualitative prediction, but it cannot explain such a large drop in inflation persistence without a change in the process for demand shocks.

Several caveats should be kept in mind[12]. First, competition is hard to measure. There is simply no credible way to estimate the level of markups[13]. There is, however, some evidence supporting the thesis of an increase in competition: Blanchard and Philippon (2002) report that barriers to entrepreneurship (in the US) have been declining since the late 1970's, and that openness to trade has been increasing since the 1960's. Both evolutions should have

[10] Nominal rigidities amplify demand shocks, but they also tend to dampen supply shocks. The competition hypothesis, however, does not need to rely on the sticky price model to explain the facts: Most models of counter-cyclical markups (see Rotemberg and Woodford (1999) for a review of these models) would predict diverging trends for macro and firm volatilities. Essentially, this will be true as long as the elasticity of the markup with respect to aggregate shocks decreases with the degree of competition. A potential advantage of models of counter-cyclical *desired* markups is that, unlike the sticky price model, they amplify all shocks, not only the demand shocks.

[11] As explained above, the interpretations for the shocks include money demand and supply shocks, as well as shocks to consumers' impatience to consume.

[12] The model is such that labor productivity is constant over time. However, I do not view this as a serious issue since it is well known that labor hoarding and capacity utilization create biases in short run estimates of labor productivity and TFP. Note also that models of endogenous capacity utilization (see King and Rebelo (1999)) predict that a decline in output volatility should be accompanied by a similar decline in the volatility of measured TFP, irrespective of where the decline in volatility is coming from. In other words, if I augmented this simple model with variable utilization, it would predict the observed decline in the volatility of the Solow residual.

[13] The profit rate is not a good proxy since product market rents can be appropriated by labor (see Blanchard and Philippon (2002) for a discussion and some evidence)

increased the degree of competition in the goods market.

A second caveat is that there is no consistent data to test the prediction that the frequency of price changes has increased over time: The new data set of Klenow and Kryvtsov (2003) covers only the period 1988-2003.

Finally, keeping the process for aggregate shocks constant, models with sticky prices tend to explain the decrease in real volatility by an increase in price level volatility. The data show, however, that both inflation and real output have become less volatile. To reconcile the model with the data, one would need to assume that monetary policy has also become more efficient. While this explanation is plausible (see Clarida, Gali, and Gertler (2000)), it is outside the scope of this paper. An intriguing question for future research is how changes in competition affects optimal monetary policy.

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Table 1: Regressions of Volatility of Firm's Sales on Controls and Time dummies. The first 2 regressions use OLS. The last one uses absolute deviation from the median (quantile regression). Source: Compustat.

Method	ols		ols		median	
	Coeff	*t-stat*	**Coeff**	*t-stat*	**Coeff**	*t-stat*
Variables						
Time Dummies						
1965 to 1970 (omitted)	**0**	*0*	**0**	*0*	**0**	*0*
1971 to 1975	**0.031309**	*4.84*	**0.032308**	*5.12*	**0.044375**	*5.83*
1976 to 1980	**0.018945**	*3.01*	**0.020733**	*3.34*	**0.038201**	*5.15*
1981 to 1985	**0.070105**	*12.68*	**0.0766**	*14.13*	**0.074074**	*11.4*
1986 to 1990	**0.106427**	*19.8*	**0.112473**	*21.4*	**0.099571**	*15.76*
1991 to 1995	**0.125278**	*24.08*	**0.134452**	*26.22*	**0.105331**	*17.23*
1996 to 2001	**0.151249**	*28.82*	**0.153987**	*29.88*	**0.150894**	*24.48*
Controls						
Industry	**1-digit (7)**		**2-digits (48)**		**1-digit(7)**	
Age	**log(age)**		**40 age dummies**		**log(age)**	
R2	0.1932		0.2608			
N	18343		18343		18343	

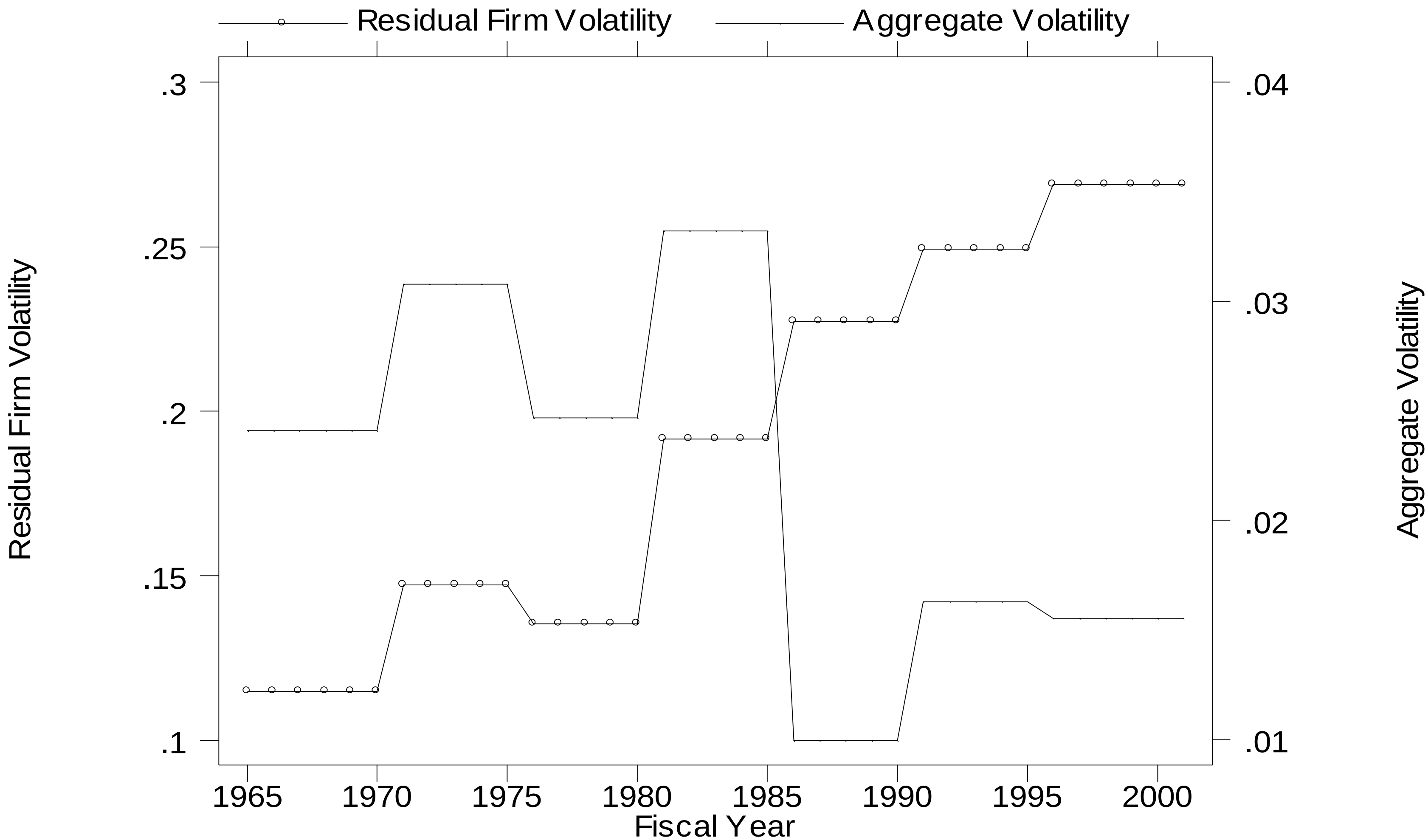

Fig. 1: Volatilities estimated over windows of 5 years

Aggregate Volatility is volatility of log growth rate of GDP. Residual Firm Volatility is volatility of log growth rate of sales, net of aggregate shocks and controlling for sector and firm age. Data: NIPA and COMPUSTAT.

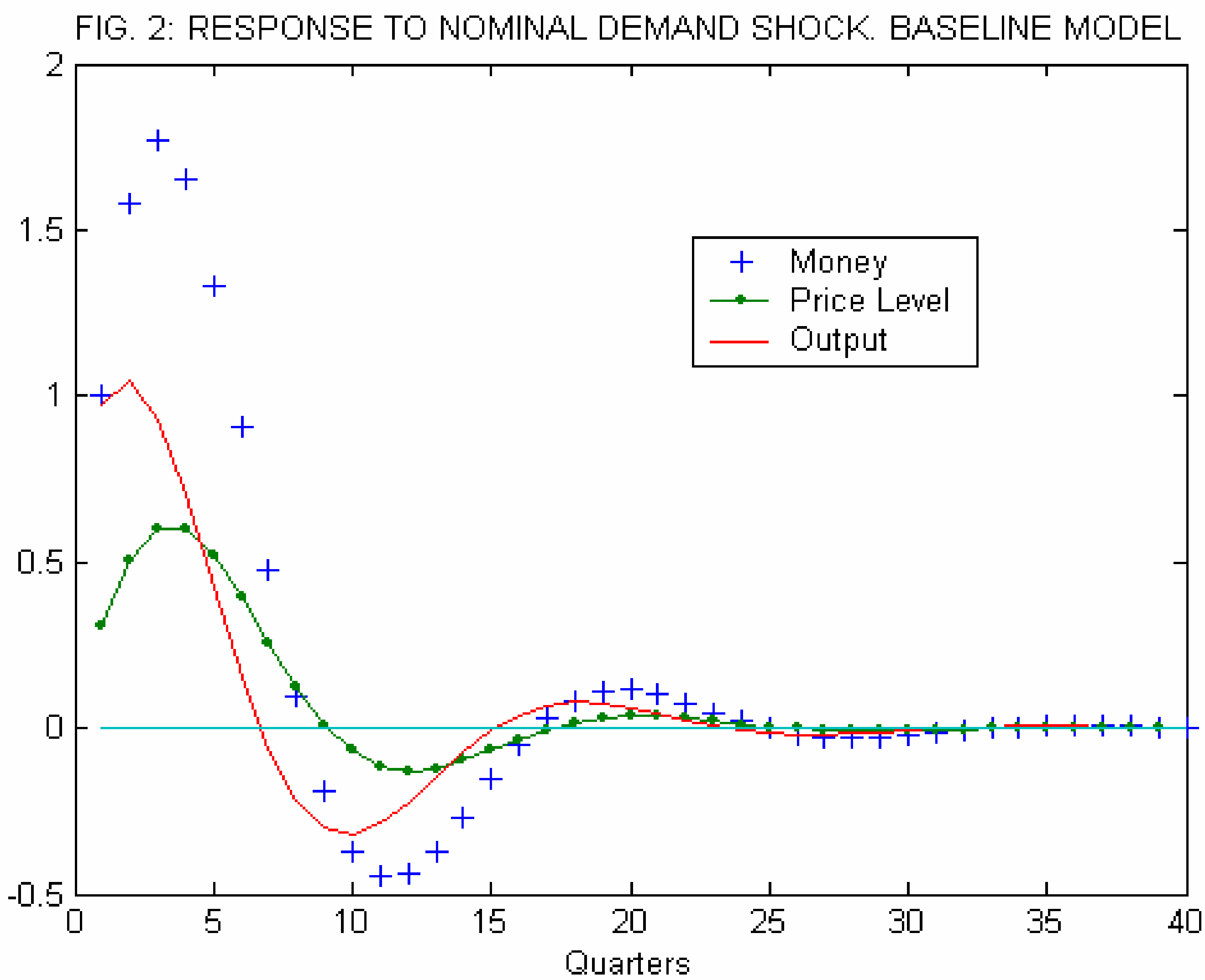
FIG. 2: RESPONSE TO NOMINAL DEMAND SHOCK. BASELINE MODEL
2
1.5
1
0.5
0
-0.5
0
5
10
15
20
25
30
35
40
Quarters
Money
Price Level
Output

FIG. 3: PROFIT LOSSES AS FUNCTION OF FIRM AND AGGREGATE LAMBDA

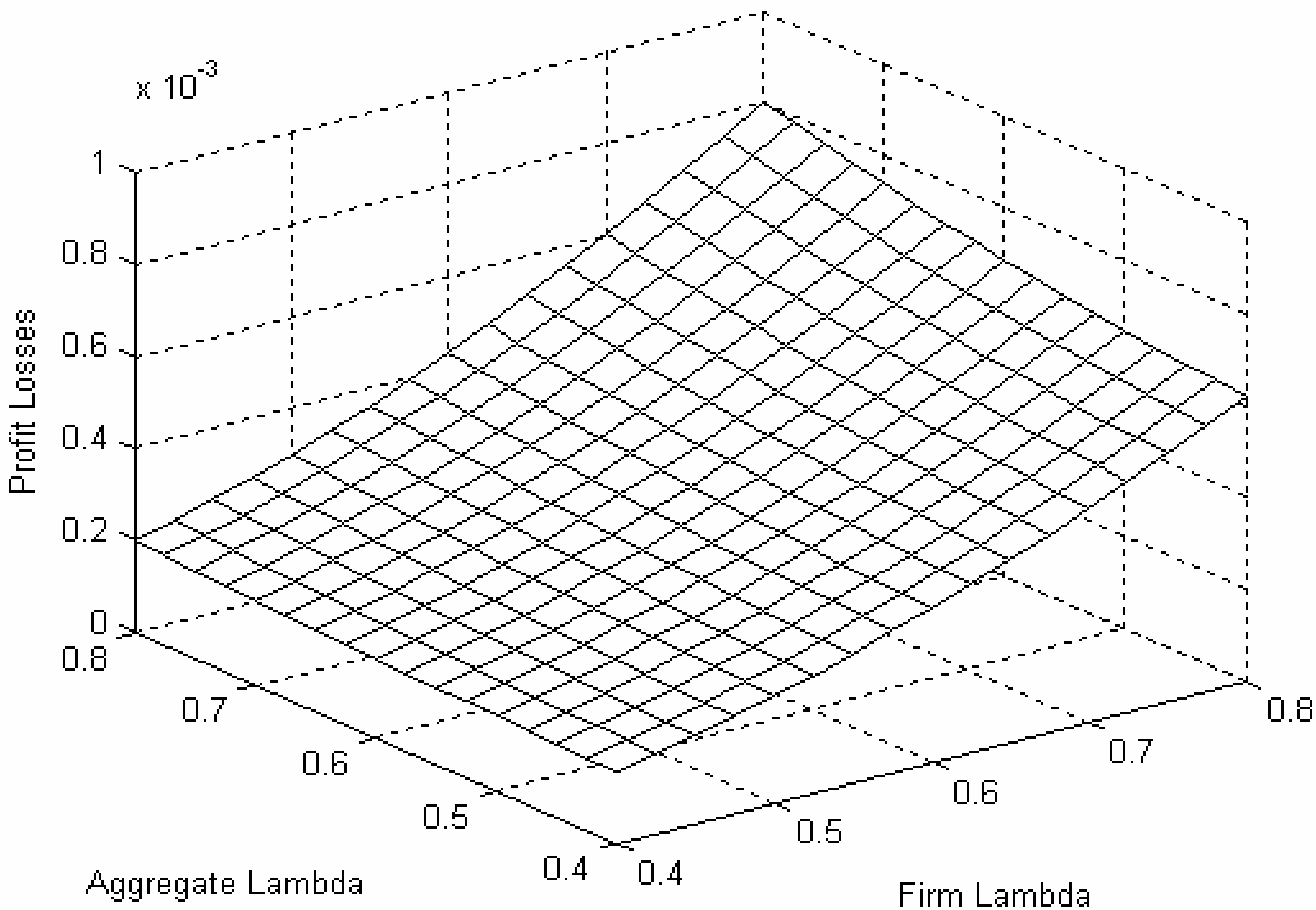

FIG. 4: NASH EQUILIBRIUM CHOICE OF LAMBDA

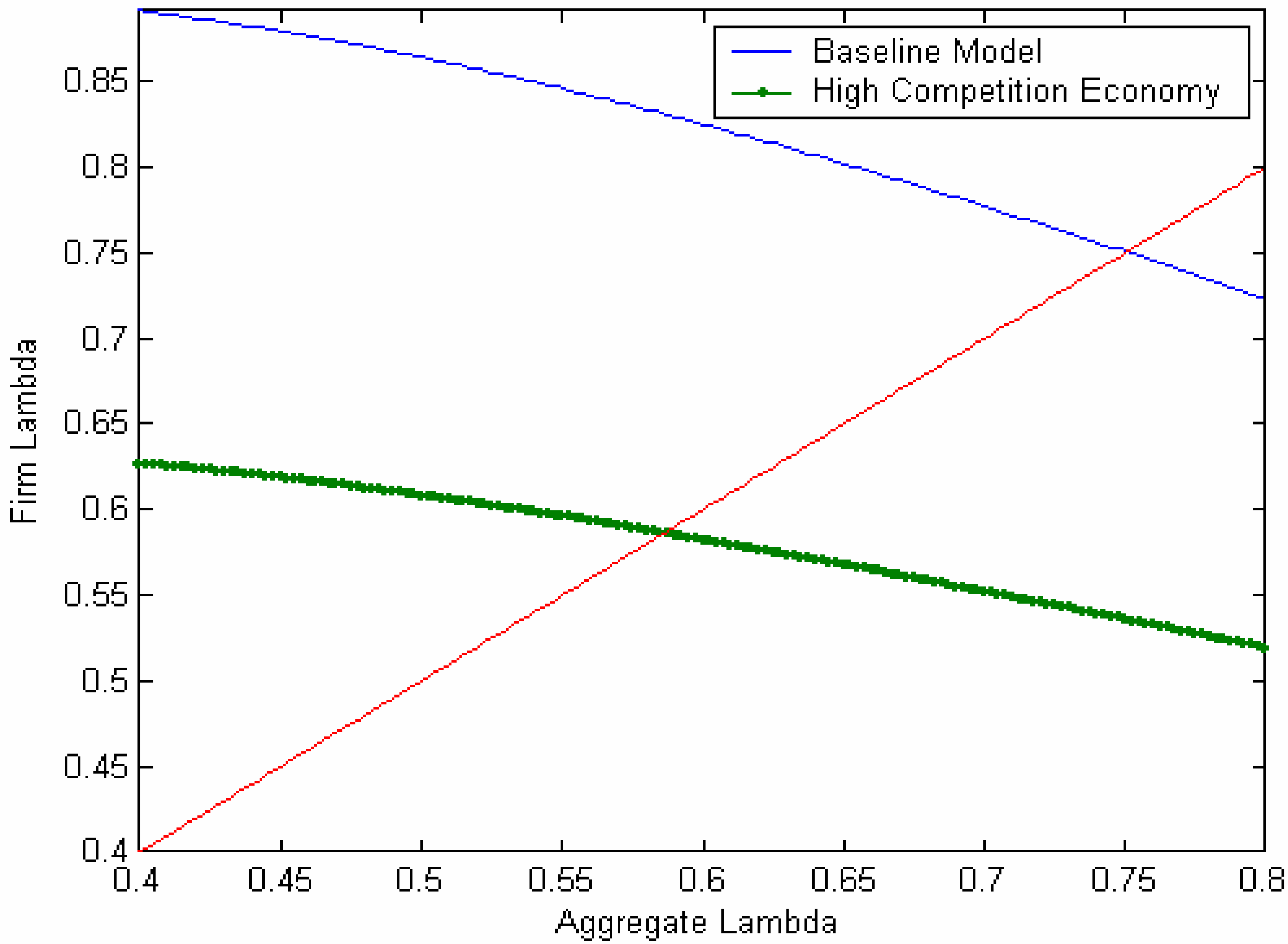

FIG. 5: RESPONSE OF REAL GDP TO DEMAND SHOCKS

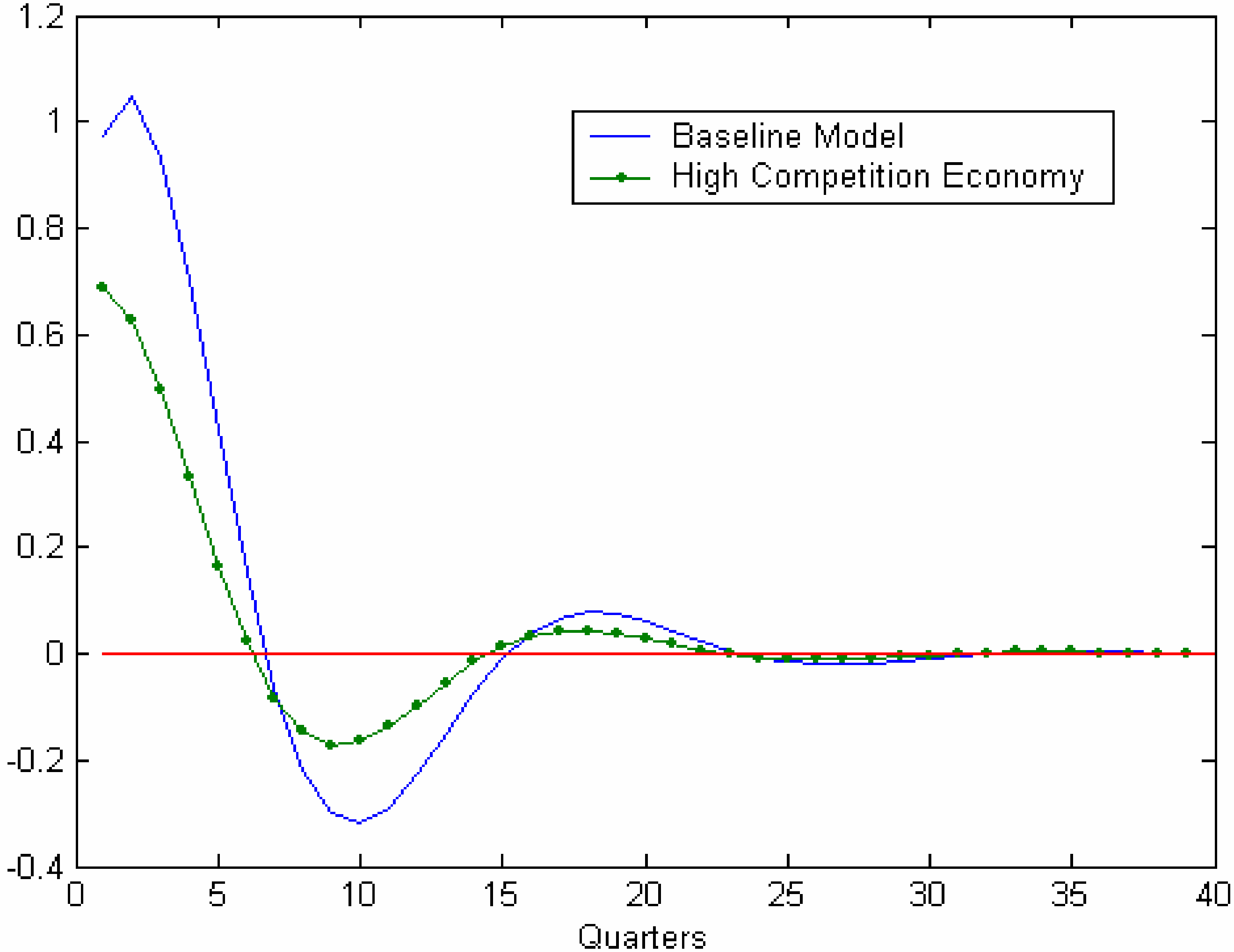

FIG. 6: RESPONSE OF PRICE LEVEL TO DEMAND SHOCKS