Product Recalls, Market Size and Innovation in the Pharmaceutical Industry

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Abstract

The idea that research investments respond to market rewards is well established in the literature on markets for innovation ([7], [1], [2]). Empirical evidence tells us that a change in market size, such as the one measured by demographical shifts, is associated with an increase in the number of new drugs available ([1];[4]). However, the debate about potential reverse causality is still open ([3]). We analyze market size's effect on innovation as measured by active clinical trials. The idea is to exploit product recalls, an innovative instrument tested to be sharp, strong, and unexpected. The work analyses the relationship between US market size and innovation at the ATC-3 level through an original dataset and the two-step IV methodology that [5] proposed. The results reveal a robust and significantly positive response of several active trials to market size.

Data

The source of sales data was PHID database. Sales data regard the US pharmaceutical market and range from 2004 to 2015 at ATC-4 level. A considerable drop in Trials and IND occurred after 2013 due to the well-known innovation crisis in the pharmaceutical. Recalls data have been manually collected from different sources, among which FDA Reports, openFDA, FOIA agreement, various articles, and web sources (e.g., [6]; WHOCC website, PubMed, [8] and others). The collected recalls turn out to be representative as compared with the benchmark number of recalls. Furthermore, recalls do not necessarily happen in more innovative markets.

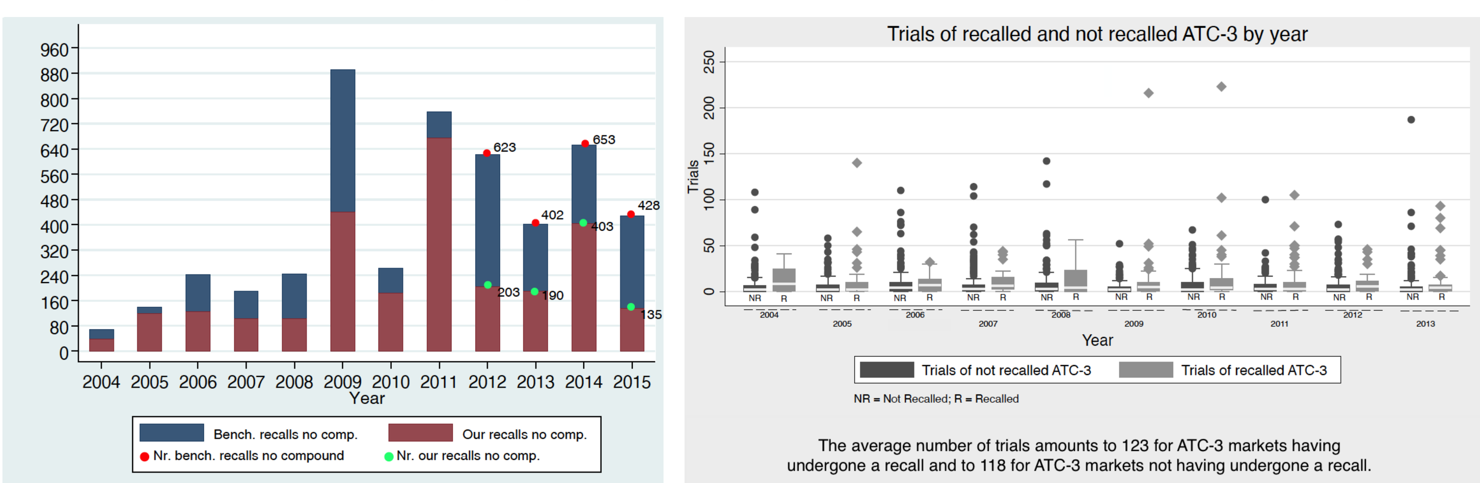

Fig. 1: Recalls are representative and exogenous.

Methodology

We employed a novel Control Function Poisson FE-IV approach ([5]) to control for the endogeneity due to correlation of covariates with time-constant, unobserved heterogeneity and that due to reverse causality of market size and innovation. Denoting as κ_{it} the idiosyncratic shock and c_i the individual heterogeneity, the unobserved effects non-linear model looks as follows:

$$E[N_{it}|M_{it}, z_{it}, c_i, \kappa_{it}] = c_i exp(x_{it}\beta_1 + \kappa_{it}) \quad (1)$$

where $x_{it} = (M_{it}, z_{it})$. z_{it} would typically include a full set of time effects and M_{it} is the endogenous variable, market size. Market size is instrumented through normalized recalls where the normalization is on number of drugs in an ATC-3 market to avoid the endogeneity arising from the fact that more populated markets are more prone to recalls. The presence of the reverse causality can be easily tested as follows assuming as $H_0: M_{it} = z_{it}\Pi + c_{i2} + u_{it2} \quad \forall t = 1, \ldots T$:

1. Estimate the fixed effects residuals $\ddot{u}_{it2} = \ddot{M}_{it} - \ddot{z}_{it}\hat{\Pi}$
2. Use fixed effects Poisson on the mean function

$$E[N_{it}|M_{it}, z_{it}, c_i, \ddot{u}_{it2}] = c_i exp(x_{it}\beta_1 + \ddot{u}_{it2}\rho)$$

use robust Wald test of $H_0: \rho = 0$

Results (first stage)

First stage results highlight the relevance of recalls as significant instrument of market size:

	(ATC-Firm Aggregation) Log sales	(ATC-3 Aggregation) Log sales
$\tilde{recalls}$	−0.0053	−0.0283***
	(0.0033)	(0.0056)
$\tilde{recalls}_{t-1}$	−0.0267**	−0.0267***
	(0.0083)	(0.0070)
$\frac{K_{t+1}}{P_{-1}}$		0.1932**
		(0.0628)
average age firm		0.1576
		(0.0921)
average age firm^2		−0.0020
		(0.0013)
hhi		1.2405***
		(0.2590)
share generics in ATC		−0.1895
		(0.3373)
papers		−0.0260
		(0.0507)
# firms		0.0077
		(0.0071)
Year Dummies	Yes	Yes
Obs.	48915	1664
Groups	8634	208

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

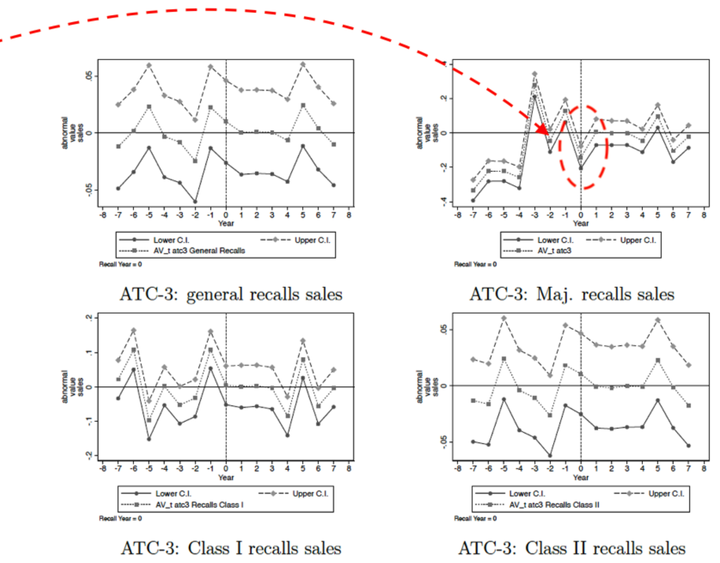

Fig. 2: Negative effect of recalls on ATC-3 sales

We believe that the key reason for the strength of the result relies on the level of aggregation. While firms with high-quality managements and inclined to risk can promptly make up for severe recalls, the latter take ATC-3 markets unaware.

Results (second stage)

In the following we report the results concerning the relationship between market size M_{it} and innovation N_{it}. Innovation is measured with the number of active trials in ATC-3. The regressors comprise supply-side determinants, technological opportunities, and age determinants.

	(1) Trials	(2) Trials	(3) Trials	(4) *log Trials*	(5) Trials
$trials_{t-1}$			−0.00741	0.0732*	
			(0.0005)	(0.0335)	
Log sales	0.1378***	0.6362**	0.802**	0.1176***	0.8229**
	(0.0060)	(0.2149)	(0.266)	(0.0153)	(0.3174)
residuals		−0.8018***	−0.862**		−0.9711**
		(0.2157)	(0.269)		(0.3177)
$\frac{K_{t+1}}{P_{-1}}$	−0.5378***	−0.0926	−0.484***	−0.0504	
	(0.0847)	(0.0909)	(0.147)	(0.0914)	
average age firm	0.2890***	−0.1332***	−0.106*	0.0634**	
	(0.0139)	(0.0377)	(0.0398)	(0.0214)	
average age firm^2	−0.0038***	0.0021***	0.00178***	−0.0008**	
	(0.0002)	(0.0005)	(0.0005)	(0.0003)	
hhi	0.2245***	−0.3199	−0.145	0.1106	
	(0.0446)	(0.2903)	(0.360)	(0.1153)	
share generics in ATC	−0.5571***	−0.3168**	−0.898***	−0.2036	
	(0.0404)	(0.1124)	(0.143)	(0.1068)	
average age product	−0.0658***	−0.0592**	−0.0928**	−0.0564***	
	(0.0061).	(0.0190)	(0.0323)	(0.0143)	
average age product^2	0.0010***	0.0011	0.0100	0.0010*	
	(0.0002)	(0.0010)	(1.64)	(0.0004)	
papers	0.5608***	0.1558*	0.101	−0.0443	
	(0.0728)	(0.0750)	(0.0013)	(0.1477)	
papers^2	−0.6672***	−0.0067	−0.0929	−0.0083	
	(0.1056)	(0.0838)	(0.083)	(0.0883)	
# firms	0.0090***	0.0008	−0.0032	0.0048**	
	(0.0007)	(0.0035)	(0.0792)	(0.0016)	
Year Dummies	Yes	Yes	Yes	Yes	Yes
Obs.	1664	1664	1664	1664	1872
Groups	208	208	208	208	208

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Fig. 3: Col.(1) employs a simple Poisson model not considering fixed effects. Col.(2) is the main specification (fixed effect Poisson). Col.(3) and Col.(4) add the lag of the dependent. Col.(5) eliminates all the controls

Discussion

The coefficients of interest are Log sales and residuals. The former representing market size, and the latter measuring endogeneity of market size. Endogeneity is tested with a Wald test on the coefficient ρ of residuals. If ρ is significantly different from zero, idiosyncratic endogeneity is present. This latter instance occurs in our model as expected (Column (2)).
According to our estimate, a 10% increase in market size leads to an increase of almost 6.3 % of active trials.

Robustness Checks

Several robustness checks have been investigated throughout the analysis. Below we report the results for the most important coefficients

	Two-step GMM *log Trials*	All recalls (First stage) *log Sales*	All recalls (Second stage) Trials	Evaluate data Trials	Log Patients as proxy of M_{it} Trials
recalls		0.001			
		(0.640)			
$recalls_{t-1}$		−0.022***			
		(−3.340)			
$trials_{t-1}$	0.059				
	(0.042)				
Log sales	0.1208***		0.580*	0.710**	
	(0.159)		(2.020)	(0.275)	
Log Patients					3.274***
					(0.648)
residuals			−0.739*	0.724***	−3.291*
			(−2.130)	(0.263)	(0.647)
Year Dummies	Yes	Yes	Yes	Yes	Yes
Obs.	1664	1664	1664	1056	1056
Groups	208	208	208	132	132

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Conclusion

The present work adopts a novel instrument, recalls, for market size to overcome the critiques of [3] to [1] instrument. It does so at the ATC-3 level, usually employed by antitrust authority and using an innovative methodology. The results detect an increase in the innovation of 6.3% after an increase in market size of 10%.

References

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