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The Investment Process in the Mexican Industry: The Case of Mexican Chemical Petrochemical Complex

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Abstract: The aim of this paper is to analyze the investment process of the mexican chemical petrochemical industry (CQP). In order to do it we take the defined complex following Lifschitz and Zottele [1] methodology and we apply a tobin's q model with uncertainty following bo [2] proposal. the main conclusions of the study are: q theory model behaves pretty good to explain investment process in the mexican CQP; tobin's q is a very important factor of the investment process; every percent change of q increases investment between 2% to 5%; uncertainty negatively affects CQP investment from -0.6% to -2% for one percent change in gross profit. One of the contributions of the paper is the application of q model at industry level.

Keywords: Petrochemical industry; investment; q model; mexican economy.

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1. INTRODUCTION

Investment process has been analyzed in the past by several views. It is a very important economic issue since its condition either allows economic growth or inhibits it. In fact, there is no other way to increase production capacity but with investment. The Mexican economy has not been able to increase its growth potential during the past three decades. Its rate of growth has been around 2.4% annually, proved insufficient given the rate of population growth. Because of these considerations we want to explore the sources of this crucial process at an industry level.

We have chosen the Chemical Petrochemical industry because it delivers a huge amount of inputs to the manufacturing sector, conditioning its economic dynamics and through there to the whole economy. Because of the productive conditioning that the Chemical Petrochemical industry has over the Mexican economy, it has been considered a key sector Armenta [3], that is, a cluster where real transformation relations with the rest of the manufacturing process fosters a positive or negative contagion generating economic growth. This type of blocks considers productive activities with strong input-product interrelationships as a differentiator for the membership or not of it. The choice of sector implies discriminating among a set of blocks or industrial complexes.

The identification of key sectors in the foregoing sense has been made using the traditional model of Leontief and exerting changes in aggregate demand. Different statistical models were applied to substantiate the role of the Mexican Chemical Petrochemical industry within the manufacturing context. One of them is a simulation using the input-output matrix disaggregated to 17 sectors with a change in the different components that make up the final demand for analyzing the impact this would have on the rest of the manufacturing sectors.

Productive sectors with greater backward chaining and forward rates measured with standardized interdependence index in the Mexican economy are two: "basic metals" and "chemical and petroleum substances." Of these two sectors, the most forward chaining is the petrochemical block. This is also the second most important block in backward chaining Armenta [3]. The Chemical Petrochemical Complex (CQP) is the set of industrial activities closely related in terms of input-output; thus it is part of the block of member activities in basic and secondary chemical industry, petrochemical industry base, generating inputs for other manufacturing activities as well as final goods. In terms of the System of National Accounts of 1993, the conglomerate consisted of nine branches that made up the Division V, except for pharmaceutical activity[1]. Table 1 shows the Description of the branches in the complex.

The aim of this paper is to analyze the investment process of the Mexican Chemical Petrochemical Industry. In order to do it we take the defined Chemical Petrochemical Complex following Lifschitz and Zottele [1] methodology and we apply a Tobin's Q Model with uncertainty following Bo [2] proposal.

The paper has been organized as follows. First section presents the literature review of investment theory, as well as the model used in this study. The second section describes the data that has been applied for the Mexican case. The third section describes the results of Tobin's Q theory. On the other hand, the fourth section presents what the model has to say about investment spending prospects for CQP over the next ten years, given specific assumptions and scenarios. Finally, we present the general conclusions.

2. METHODOLOGY

2.1 Literature Review

Economics literature defines investment as the expenditure made by firms in order to keep or increase their productive capacity plus the expenses generated by the need of applying new technologies to improve efficiency Shapiro [4]. These decisions are negatively related to the cost of the implied resources but positively related to the behavior of sales. In Brainard and Tobin [5] words, investment is stimulated when capital value is greater than its cost to produce it, but if the market value is less than the replacement cost, then investment is discouraged. Investment theory has been

[1] The classification of Manufacturing Activities in the Mexican Economy has been changed in different periods due to update processes by INEGI, the Mexican Institute of Statistics and Geography, but we have followed the main concepts in order to keep the analysis of this conglomerate through the time.

dominated by different views: the Accelerator Model, the Cash Flow Model, the Neoclassical Model and the Tobin's Q Theory just to mention the most commonly used.

The Accelerator Model postulates a linear relationship between net investment and changes in output. According to Bischoff [6], antecedents of the model go back at least to Clark [7] and modified by many authors, among others Chenery [8], Koyck [9] and Hickman [10]. The model has been developed as a relationship between output, levels and changes, and the level of the existing capacity or capital stock. The special characteristic of this model is that the only variable that explains the planned capital stock is output. This implies technological rigidity since it only allows one capital/output ratio. The Accelerator Model of Eisner and Stroz [11] states that there is an adjustment pattern in the demand of desired capital stock. The model is then generalized by Lucas [12] for the case of multiple capital goods and multiple inputs. Eisner [13] employs the ratio of investment to gross fixed assets as dependent variable and the growth of sales, the ratio between the benefits to gross fixed assets and the ratio between depreciation and gross fixed assets as independent variables. Eisner considers an alternative model of investment for individual firms in the period 1960-1962. He introduces two additional independent variables: the market value of the firm and the rate of return; where only profits and the rate of return are significant determinants of desired capital.

In the case of the Cash Flow Model, it establishes that current and past profits are a good proxy for future profit expectations which determine investment, Klein [14]. Some models make consideration of tax treatment of depreciation so they relate investment to profits plus depreciation. Others use profits after taxes plus depreciation to emulate the cost of internal funds to finance investment, Dusenberry [15].

The Neoclassical Model developed by Jorgenson [16] is based on an optimization model that relates the desired capital stock to interest rates, production, capital price and taxes. However, the justification of resources flows in order to develop more capital is not clear. The alternative view to Jorgenson's Neoclassical Model was developed by Tobin [17]. He states that the rate of investment is a function of q, the ratio of the market value of new additional investment goods to their replacement cost. Tobin argued that the optimal rate of investment is an increasing function of the ratio of the market value of the firm to the replacement cost of the firm's capital. Mussa [18] and Abel [19] showed that the optimal rate of investment is the rate that equals the marginal adjustment cost with marginal value of installed capital, a concept known as marginal q. Since marginal q is not observable, some developments have been made in order to find a proxy.

Hayashi [20] named average q to the market value of existing capital over its replacement cost. He showed that in perfect competition when the production and adjustment cost functions are linearly homogeneous in capital and labor, average and marginal q are equal. By applying restrictions on the production function and the augmented adjustment cost function (which represents the sum of purchase or sale cost of buying or selling uninstalled capital, adjustment and fixed cost) Abel and Eberly [21] considered that it is possible that q be equal to average value of the capital stock. Abel [22] and Hayashi [20] connect investment theories at that time; they showed that the Neoclassical Model with convex adjustment cost yields to a Q Model.

Summers [23] says "Tobin assumes to a good approximation, the market value of an additional unit of capital equals the average market value of the existing capital stock, i.e. average q, which is the ratio of the market value of the capital stock to its replacement cost is a good proxy for the value of the marginal q on an additional dollar of investment" p. 77. Hayashi [20] states that the modified Neoclassical Investment Theory with installment costs and the Q Theory are equivalent and implicitly recognized first by Lucas and Prescott [24].

In this article we apply Tobin's Q Model. Summers [23] has recognized it has at least three advantages over more conventional theories: 1. On those models where the level of output is predetermined, the natural response of the firm to a reduction in the cost of capital is not taken into consideration; 2. Investment models on Flexible Accelerator view are not suitable to capture a modification of taxes paid for individuals; 3. The Q Theory is ideally suited to capture policy influence by comparing permanent versus temporary policies.

The model states that under perfect competition all relevant information should affect investment through q. Since the assumptions of the Q

Theory are difficult to meet, many efforts have been made to improve the performance of the empirical Q Model: Hayashi [20], Abel and Blanchard [25], Chirinko [26-28] Abel and Eberly [21], and Scaramozzino [29] are some of them.

Furthermore, Q Theory considers expected future profitability. Because of this, uncertainty is implicit in the model. Bo [2] tested whether the performance of the model improves by including uncertainty factors in the investment equation. He found that, in addition to q, volatility of profits and interest rate affects investment.

Following Brainard and Tobin [5], the Q Theory Model equation could be initially explained as follows:

$$q = \frac{\text{Net Value of Securities}}{\text{Acquisition Cost of Capital Stock}} = \frac{V}{pK} \qquad (1)$$

Equation (1) suggests that all fluctuations in investment are related to the ratio of the shadow value to the market price of a unit of capital. If managers seek to maximize the market value of their corporations, they will need to add fixed capital goods. This will happen whenever the marginal addition to the firm's market value exceeds the costs of the goods; that is, whenever $q > 0$. This standard methodology implies that all factors, including different aspects of uncertainty, affect corporate investment through q Blanchard and Fischer [30].

Bo [2] clearly derives the Q Model of investment with uncertainty by first obtaining the dynamic objective function of the firm using Nickell [30]'s approach. After a typical optimization process, Bo [2] states the value function of a firm under uncertainty as:

$$V_j(0) = \int_0^{\infty} e^{-rt}\left[E_0(\pi_{ji}) - \theta \mathrm{Var}(\pi_{jt})\right]dt \qquad (2)$$

Where:
r = the constant discount rate faced by the firm j, measured in real terms
E_0 = expected operator based on the information available at time t = 0
θ = the market price of risk

The value of a firm j is equal to the expected present value of the future income stream generated by the firm j at time t less the total cost of the risk associated with the particular income stream. Equation (2) is implicitly based on two big assumptions: first, there are no agency costs between the stockholders and the managers of the firm; and second, we further assume that the price of capital goods equals the price of consumption goods. It's also important to state that Bo [2] measures the amount of risk by introducing a cost function of uncertainty instead of using the variance of profits directly.

In order to proceed with the empirical analysis, the author derives a function of the Q Model that can be estimated by redefining parameters, setting up a Hamiltonian function and finally applying first order conditions to such objective function. Equation (3) shows the empirical Tobin's Q Model with uncertainty.

$$\frac{I_t}{K_t} = \beta_1 + \beta_2 q_t + \beta_3 SD(\pi_t) + \varepsilon_t \qquad (3)$$

Therefore, the investment trajectory of a firm given by the rate of gross investment to capital stock is determined by marginal q and the standard deviation of profits. In order to proceed with the estimation of Equation (3), we first need to state some concerns and specifications regarding the data in the following section.

2.2 Data

We used data of the Industrial Survey compiled by INEGI, the National Institute of Statistics and Geography of Mexico. Originally, the data was arranged in a balanced panel of 95 observations that accounted for the CQP in the period of 1994-2012. Nevertheless, after first calibration and estimation of our model, data didn't bring meaningful evidence of the theory, mainly because it was aggregated as the sum of the nine branches of the CQP. Consequently, data was rearranged in three balanced panels for the periods of 1994-2003 (300 observations), 2003-2009 (280 observations) and 2009-2012 (160 observations), following the initial structure of the survey at the branch level, with information of the System of National Accounts of 2008. Table 2 shows the detail of panel data.

Regarding the *net value of securities*, V, we used data of the total credit employed by the CQP through the commercial and developing banking because PEMEX subsidiaries and private companies of this industry are not all listed in the stock exchange. To disaggregate credit data at the branch level, we used a coefficient given by the gross investment in fixed assets by each branch as a proportion of the class that they belong to.

Table 1. Mexican chemical petrochemical complex, 1993

33 Petroleum. Regeneration of oils and asphalts.
34 Basic Petrochemicals.
35 Basic Chemistry. Dyes and pigments. Industrial gases.
36 Fertilizers.
37 Synthetic resins and artificial fibers.
39 Soaps, detergents and cosmetics.
40 Other Chemicals. Insecticides and pesticides. Paints, varnishes and lacquers. Waterproofing and adhesives. Inks and polishes.
41 Rubber tires and tubes vulcanization.
42 Plastic products. Packaging and laminates. Other plastic molding products.

Note: The classification of the branches corresponds to that used by INEGI. System of National Accounts. Division V: Chemicals, Petroleum, Rubber and Plastic. 1993. The branch 38 Pharmaceutical products had been excluded from CQP due to the low content of basic petrochemicals and chemical inputs required productively. The definition of the Complex follows Lifschitz and Zottele [1] Methodology called "Productive Chains and Oligopolistic Markets"

Table 2. Panel data: Mexican CQP at branch level, 1994-2012

Industrial survey: 1994-2003		**Real gross investment (I)**	**Capital stock (K)**	**Tobin's Q**	**Profit (π)**	**Uncertainty (var (π))**
3512 Basic chemistry (excludes basic petrochemicals)	1994	48.71	1,392.37	1.60	209.92	-0.31
	1995	86.85	1,029.25	1.96	319.78	0.52
	1996	72.30	899.46	1.63	256.47	-0.20
	1997	53.62	749.93	1.09	212.67	-0.17
	1998	35.82	687.01	0.77	195.82	-0.08
	1999	40.36	584.37	1.19	175.54	-0.10
	2000	59.33	628.54	1.48	117.23	-0.33
	2001	20.43	680.85	1.16	116.11	-0.01
	2002	24.06	730.23	0.68	122.24	0.05
	2003	17.77	593.14	0.96	143.48	0.17
3513 Synthetic and artificial fibers	1994	29.74	1,182.79	1.15	26.35	-0.59
	1995	45.31	829.09	1.27	71.49	1.71
	1996	36.30	650.30	1.13	77.57	0.09
	1997	33.15	560.34	0.90	61.00	-0.21
	1998	51.47	622.09	1.21	20.81	-0.66
	1999	22.24	444.27	0.86	25.74	0.24
	2000	12.03	324.47	0.58	31.70	0.23
	2001	1.34	287.18	0.18	25.46	-0.20
	2002	10.50	298.68	0.73	19.71	-0.23
	2003	4.40	259.91	0.54	32.20	0.63
3522 Other chemicals	1994	33.22	133.26	11.40	309.46	0.16
	1995	42.47	89.79	10.99	264.76	-0.14
	1996	32.73	70.85	9.35	256.10	-0.03
	1997	46.73	62.35	11.41	265.32	0.04
	1998	49.45	62.02	11.63	281.69	0.06
	1999	53.09	53.98	16.89	293.30	0.04
	2000	32.52	44.66	11.43	290.75	-0.01
	2001	14.10	40.41	13.53	285.38	-0.02
	2002	24.15	42.04	11.87	306.60	0.07
	2003	14.02	42.98	10.49	300.73	-0.02
3540 Coke, other derivatives of coal and crude oil	1994	4.74	103.22	2.10	46.10	0.13
	1995	9.29	79.84	2.70	44.70	-0.03
	1996	6.73	66.30	2.05	34.48	-0.23

	1997	10.02	79.94	1.91	25.74	-0.25
	1998	7.72	67.29	1.67	36.92	0.43
	1999	3.02	44.53	1.17	35.13	-0.05
	2000	4.50	36.82	1.92	33.74	-0.04
	2001	1.38	29.70	1.80	39.95	0.18
	2002	4.57	32.57	2.90	35.27	-0.12
	2003	0.75	29.09	0.83	37.47	0.06
3550 Synthetic resins and rubber	1994	6.38	180.32	1.62	48.25	-0.36
	1995	15.16	107.95	3.62	64.74	0.34
	1996	10.68	100.14	2.16	65.94	0.02
	1997	13.09	86.98	2.29	64.62	-0.02
	1998	21.02	109.32	2.80	58.49	-0.09
	1999	15.26	113.11	2.32	41.30	-0.29
	2000	12.38	70.52	2.76	36.18	-0.12
	2001	0.64	72.80	0.34	23.84	-0.34
	2002	5.79	49.41	2.42	25.03	0.50
	2003	1.53	49.38	1.00	28.47	0.14
3560 Plastic products	1994	48.49	1,109.75	2.02	75.50	-0.24
	1995	41.19	745.26	1.28	100.01	0.32
	1996	28.59	571.05	1.01	106.58	0.07
	1997	34.32	509.04	1.03	112.86	0.06
	1998	47.46	534.59	1.30	95.08	-0.16
	1999	37.90	455.14	1.43	93.25	-0.02
	2000	34.56	402.09	1.35	92.25	-0.01
	2001	23.13	350.31	2.56	91.84	0.00
	2002	33.17	392.24	1.75	81.77	-0.11
	2003	19.63	318.81	1.98	91.31	0.12
Industrial Survey: 2003-2009		**Real Gross Investment (I)**	**Capital Stock (K)**	**Tobin's Q**	**Profit (π)**	**Uncertainty (var (π))**
3251 Basic chemistry	2003	55.50	638.44	1.09	338.97	-0.29
	2004	46.07	565.96	1.22	569.78	0.68
	2005	26.64	506.34	1.46	576.99	0.01
	2006	36.00	506.32	1.20	532.37	-0.08
	2007	50.58	511.53	2.12	439.61	-0.17
	2008	23.75	492.18	1.79	517.92	0.18
	2009	28.34	506.41	2.61	437.10	-0.16
3252 Resins and chemical fibers	2003	32.94	241.45	1.83	51.04	-0.31
	2004	17.30	242.40	1.07	83.84	0.64
	2005	3.44	219.45	0.43	108.49	0.29
	2006	20.81	222.93	1.58	80.10	-0.26
	2007	7.10	212.62	0.71	93.31	0.16
	2008	4.42	179.53	0.91	115.60	0.24
	2009	2.32	170.60	0.63	75.23	-0.35
3253 Fertilizers, insecticides and pesticides	2003	4.28	27.20	2.11	15.44	0.78
	2004	4.32	28.50	2.27	13.78	-0.11
	2005	0.35	26.60	0.36	20.11	0.46
	2006	0.05	25.83	0.03	20.52	0.02
	2007	2.14	25.59	1.79	23.69	0.15
	2008	4.35	25.57	6.29	28.55	0.21
	2009	1.47	22.54	3.04	28.29	-0.01
3255 Paints, varnishes and lacquers. Waterproofing and adhesives	2003	3.74	47.08	1.07	39.93	0.04
	2004	4.34	51.84	1.25	40.75	0.02
	2005	3.62	50.38	1.99	52.03	0.28
	2006	4.33	50.17	1.46	48.33	-0.07

	2007	2.05	48.74	0.90	53.79	0.11
	2008	3.08	47.16	2.42	52.62	-0.02
	2009	2.04	46.85	2.03	49.53	-0.06
3256 Soaps, detergents and cosmetics	2003	12.73	87.47	1.95	130.16	0.08
	2004	8.33	94.55	1.32	128.47	-0.01
	2005	7.78	94.19	2.29	139.58	0.09
	2006	18.08	101.82	3.00	135.41	-0.03
	2007	7.59	100.23	1.62	140.85	0.04
	2008	9.79	103.97	3.49	143.85	0.02
	2009	12.26	114.45	4.99	154.49	0.07
3259 Other chemicals	2003	2.99	35.85	1.12	13.80	-0.43
	2004	6.53	38.98	2.51	38.40	1.78
	2005	4.61	40.73	3.13	38.56	0.00
	2006	2.14	40.69	0.89	47.29	0.23
	2007	0.56	39.43	0.30	40.45	-0.14
	2008	1.23	37.55	1.21	36.48	-0.10
	2009	0.71	35.76	0.93	36.19	-0.01
3261 Plastic products	2003	22.91	305.18	1.01	95.09	-0.15
	2004	27.02	305.80	1.32	130.84	0.38
	2005	19.21	295.71	1.80	151.68	0.16
	2006	17.34	296.63	0.99	154.29	0.02
	2007	19.50	298.48	1.40	150.20	-0.03
	2008	17.56	286.42	2.27	152.12	0.01
	2009	15.98	287.36	2.59	130.63	-0.14
3262 Rubber products	2003	4.26	42.62	1.26	20.07	0.05
	2004	7.12	48.66	2.19	24.37	0.21
	2005	4.58	49.18	2.57	25.99	0.07
	2006	5.31	49.86	1.80	25.96	0.00
	2007	2.99	49.94	1.28	29.86	0.15
	2008	6.01	48.61	4.58	30.62	0.03
	2009	0.07	49.53	0.06	28.30	-0.08
Industrial Survey: 2009-2012		**Real Gross Investment (I)**	**Capital Stock (K)**	**Tobin's Q**	**Profit (π)**	**Uncertainty (var (π))**
3251 Basic chemistry	2009	55.81	518.23	2.80	330.82	0.24
	2010	24.12	552.60	1.10	335.30	0.01
	2011	28.54	556.15	1.53	461.56	0.38
	2012	82.67	602.13	3.15	396.67	-0.14
3252 Synthetic resins and artificial fibers	2009	5.36	229.15	0.61	99.52	0.33
	2010	6.98	222.70	0.79	115.04	0.16
	2011	8.55	229.05	1.11	106.73	-0.07
	2012	7.58	201.28	0.86	141.46	0.33
3253 Fertilizers, insecticides and pesticides	2009	0.81	33.21	0.64	44.41	-0.02
	2010	2.16	32.52	1.67	48.04	0.08
	2011	4.90	30.93	4.72	50.11	0.04
	2012	4.94	32.05	3.54	45.57	-0.09
3255 Paints, varnishes and lacquers. Waterproofing and adhesives	2009	0.09	42.13	0.05	59.34	0.17
	2010	4.24	42.94	2.48	72.95	0.23
	2011	4.23	40.45	3.11	80.68	0.11
	2012	2.90	40.36	1.65	77.69	-0.04
3256 Soaps, detergents and cosmetics	2009	17.56	132.22	3.46	263.45	-0.04
	2010	26.43	143.23	4.64	257.25	-0.02
	2011	23.57	152.85	4.59	263.12	0.02
	2012	22.14	168.43	3.01	246.80	-0.06
3259 Other chemicals	2009	0.43	38.95	0.29	43.61	-0.19

	2010	2.89	38.13	1.90	40.51	-0.07
	2011	3.40	37.35	2.71	34.69	-0.14
	2012	1.72	43.58	0.90	29.41	-0.15
3261 Plastic products	2009	26.61	440.04	1.57	170.02	0.06
	2010	31.27	428.92	1.83	216.12	0.27
	2011	33.85	419.87	2.40	226.86	0.05
	2012	37.39	435.24	1.97	210.39	-0.07
3262 Rubber products	2009	7.24	90.18	2.09	29.18	1.45
	2010	5.14	98.20	1.32	37.28	0.28
	2011	7.44	82.77	2.68	74.83	1.01
	2012	12.52	84.95	3.38	71.81	-0.04

Data source: Industrial Survey; INEGI

Particularly, the Industrial Survey of 1994-2003 doesn't bring data of the *capital stock*, K; it only brings the flow of capital for each of the years at the branch level. In order to have a time series with the stock arrangement, we used 2003 total stock data from the Industrial Survey of 2003-2009. However, we had to take an additional consideration: the total number of economic activities of both editions of the survey differs; the 1994-2003 survey classifies the total economy in 205 classes, while the 2003-2009 survey uses 231 classes. Therefore, we had to consider the expansion factor (around 5.56) of the latest survey to accurately build the series of the capital stock from 2002 backwards down to 1994.

With data of V and K we could compute Tobin's Q at the branch level. For the rest of the variables, we used the price deflator given by the *producer price index*, PPI of the CQP. In that way, we obtained the *real gross investment*, I, and constructed the *real gross profit function*, π given by:

$$\pi_{it} = s_{it} - f_{it} - dep_{it} - w_{it} - inp_{it} - r_{it} \quad t = 1994, \dots, 2012 \qquad (4)$$

Where:
i = CQP branch
s = total sales
f = expenditure in fixed assets
dep = cost of depreciation
w = labor costs (wages)
inp = cost of intermediate inputs
r = cost of raw materials

As it turns, our empirical test covers a sample of 740 observations from 1994 to 2012 arranged as panels of data. Table 3 presents the descriptive statistics of our variables. The table shows that Tobin's Q is very different across CQP branches, showing diverse behavior of capital decisions within the complex as economic conditions for each of these might be diverse. The mean and the median value of the net value of securities, the capital stock and the gross profit are larger for branches 3251 Basic Chemistry, 3256 Soaps, detergents and cosmetics and 3261 Plastic products as compared to their counterparts. Notice that the mean (median) value of the capital stock for 3251 Basic Chemistry is 23.1 (22.8) times that of 3253 Fertilizers, insecticides and pesticides, while the mean (median) of net value securities for 3261 Plastic products is 10.4 (9.6) times that of 3255 Paints, varnishes and lacquers, waterproofing and adhesives.

This could imply two possible situations: 1) branches with the highest amounts of capital stock benefit the most by the financial system as they could receive more credit, using their assets to support more indebtedness; 2) the interest burden of low capital stock branches could be considerably higher than that of high capital stock branches. This last consequence can be seen from the difference in the value of gross profit between high and low capital stock branches. For example, the mean (median) value of gross profit for branch 3251 Basic Chemistry is 8.4 (8.5) times that for branch 3262 Rubber products. One interesting exception is branch 3252 Synthetic resins and artificial fibers with capital stock above the mean but the net value of securities and gross profits under the mean which can be explained by the enormous world competition of this particular industry where the Asian Industry has put the Western industry in severe pressure.

In Table 3 we use Tobin's Q as an average to proxy marginal q as usual. Therefore, due to data restrictions at the company level within every branch, we are not able to avoid measurement problems of q. This requires our care in interpreting estimation results in the next section. Before proceeding with our empirical results, we need to deep in the uncertainty measure as this is a key issue of the specific model we are applying.

Table 3. Descriptive statistics: Mexican CQP, 1994 - 2012

Branches	Net value of securities (V)		Capital stock (K)		Gross profit (π)		Uncertainty (var (π))		Tobin's Q	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
3251 Basic chemistry	116,497	102,460	65,712	64,181	352	357	22.3	34.2	1.7	1.6
3252 Synthetic resins and artificial fibers	26,679	25,952	29,368	28,538	81	75	10.2	14.0	0.9	0.9
3253 Fertilizers, insecticides and esticides	7,053	6,724	2,840	2,815	25	24	1.6	1.3	2.2	2.2
3255 Paints, varnishes and lacquers. Waterproofing and adhesives	7,606	8,014	4,374	4,436	44	45	3.6	3.9	1.8	1.9
3256 Soaps, detergents and cosmetics	42,691	39,969	12,337	12,282	139	140	3.9	4.7	2.8	2.8
3259 Other chemicals	19,055	19,011	4,763	4,802	119	121	5.4	3.3	4.9	4.6
3261 Plastic products	78,865	76,574	44,028	44,126	146	152	7.1	4.9	1.7	1.6
3262 Rubber products	18,285	17,541	8,311	8,157	42	42	13.6	13.0	2.1	2.2

Data source: Own calculations from Industrial Survey; INEGI. Values in thousands of pesos, except for Tobin's Q.

2.2.1 The measurement of uncertainty

Volatility characterizes the ups and downs of a time series. The study of investment theory has derived a good number of measures of volatility as a proxy of the uncertainty component of investment behavior. In most empirical studies, the use of the standard deviation is chosen as a representation of uncertainty, Ghosal and Loungani [31], Price [32,33], Guiso and Parigi [34], Caballero and Pindyck [35].

In this study, we approached this measurement for discrete data in both estimations. Our first using one balanced panel data and the second using three balanced panels for different periods. Although our measurement structure was done by using the constructed variance as the variance of the unpredictable part of a stochastic process Aizenham and Marion [36], Ghosal [37], Ghosal and Loungani [31], Peeters [38], the main results of the estimations were not significant for any of the data arrangements, and didn't have a high goodness of fit of our model.

Therefore, we decided to use the annual rate of growth at the branch level to approximate the uncertainty component of gross profits since the behavior of sales revenue varies greatly at the branch level. The advantage of using survey data to construct this kind of measure of uncertainty is that the data directly carries the information on the companies' expectations on future variables so that our estimator of uncertainty can be considered as valuable. The choice of this technique was mainly based on data arrangement and restrictions on first estimation results. Moreover, since the uncertainty variable we use in this paper is likely to be used for relatively medium-term forecasting conclusions, we believe that using the annual rate of growth of gross profits can have the power to demonstrate the volatility of such variable.

Table 3 shows the value of the uncertainty variable as var (π). As we can see, branches with the lowest gross profits have typically faced higher uncertainty: 3252 Synthetic resins and artificial fibers, 3253 Fertilizers, insecticides and pesticides, 3255 Paints, varnishes and lacquers, waterproofing and adhesives, and 3262 Rubber products, have the highest ratio of var (π) to profit. The more critical case is shown by the branch 3262 Rubber products, in which the media (median) value of volatility has represented around 32.4% (31.1%) of gross profits. As Table 4 shows, estimation results under this measurement of uncertainty were statistically valid and significant.

3. RESULTS AND DISCUSSION

Previous to the estimation of the Model using the three panels of data, we estimated multiple regression equations between sales and expenditure in fixed assets at the branch level in order to approximate the best "lag" in such relationship. Based on Granger Causality Tests, we found that whenever the Mexican CQP increases its capital stock, sales increase in the next two years. In fact, sales sensitivity to a 1% change in capital today suggests an increase between 4.5-6.8% of sales in the next two years.

Table 4 shows the results of fixed-effects weighted ordinary least square estimations for the three samples. We should highlight that the aim of this empirical estimation is closer to a contrast of a first-order condition, in which we test whether q and other variables considered in it are significant regressors that explain investment decisions. The idea of finding an infallible structural equation of investment is not the purpose of this paper.

Considering the general performance of the variables, in general, we can rely in the theory of Tobin's Q with uncertainty since it explains and predicts the behavior of investment of the Mexican CQP pretty good. We observe three main findings. First, q doesn't carry all the relevant information to a firm's investment decisions, although it is a very important factor of the decision process. This insight is driven by the constant coefficients, as only the sample of Survey 2003-2009 shows a significant estimator at 90% confidence. Secondly, it turns out that Tobin's Q effect over investment is not very different when comparing sample estimations; q coefficients are estimated positive, around 0.02 and 0.05 with high statistically explanatory strength across different regressions.

Finally, uncertainty might affect investment but less than q. In all cases, volatility of profits is significant at 90% confidence at least. Higher disparity of companies' returns within a branch negatively affect the amount of investment in fixed capital assets, as shown by negative sign of uncertainty variable coefficients. This suggests that uncertainty factors are important in explaining investment in a Q Model for the Mexican CQP. In fact, investment sensitivity to a 1% change in uncertainty suggests a decrease between -0.6% and -2.0% of capital stock replacement today.

One important issue we tried to put aside was the autocorrelation of errors. As Table 4 shows, Durbin-Watson statistics are near the value of 2.0. The three estimations also fitted correctly using autoregressive moving averages. Nonetheless, we estimated DW limits to rule out first-degree autocorrelation, also we computed the Langrange Multiplier test of Breusch-Godfrey to discard serial correlation of higher degrees. Table 5 provides the main results of both tests.

In the case of first-degree autocorrelation, we reject the null hypothesis at 1% significance for the three survey samples. Unlike the Durbin-Watson Test, the Lagrange Multiplier Test of Breusch-Godfrey allows serial correlation of higher orders among errors. In doing so, we used the LM statistic. The evidence in Table 4 shows that for samples of Surveys 1994-2003 and 2009-2012, the Q Model shows serial correlation of second order among errors at 10% and 5% significance, as LM statistics follow a Chi-square function with associated probabilities of 0.0593 and 0.0260, respectively. This result can easily be explained with the relationship we found earlier among sales and expenditure in fixed assets at the branch level, suggesting that any difference in gross profits, and therefore var(π), will show difference in investment residuals for the next two years. We also tested serial correlation for 3, 4, 6 and 12 lags, but no additional concerns were found regarding correlation of errors. Notice that for Survey 2009-2012, the third-degree estimation also showed evidence of serial correlation, but we are sceptic about this result as this survey has the fewest observations of the three and such behavior could additionally be influenced by second-order correlation evidence.

3.1 The 2013-2022 Outlook for Investment in the Mexican CQP

One of the goals of this paper is to provide estimates up to ten years into the future regarding investment behavior of the Mexican CQP. As previously shown, Bo [2] approach performed good enough to affirm that Tobin's Q is a reliable source to understand investment spending in such industry. In order to understand what the estimated equation imply in forecasting periods, we have constructed three scenarios. Particular assumptions in each of the cases were chosen as influenced by two major structural changes in the Mexican economy. First, the approval and start of the Fiscal reform in January 1, 2014. Second, the amendments to the Mexican Constitution given by secondary laws of the new Energy reform that came into action in August 14, 2014.

Baseline scenario assumes that expenditure in fixed assets (f) in CQP grows at the same rate than the Average Annual Growth Rate (AAGR) of the period 1994-2012. The performance of the complex in such period was poor in general, total gross investment decreased 2.2% every year on average.

Table 4. Estimations of the model: Mexican CQP at branch level

$$I_t/K_t = \beta_1 + \beta_2 Q_t + \beta_3 var(\pi)_t + \varepsilon_t$$

Regressors	Industrial survey: 1994 - 2003		Industrial survey: 2003-2009		Industrial survey: 2009-2012	
	Coefficient	**t-Statistic**	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
Constant	0.0013	0.6951	0.0091	1.7240	0.0009	0.2912
q	0.0557	86.9234	0.0264	17.9064	0.0386	38.2510
var(π)	-0.0107	0.0064	-0.0207	-1.9905	-0.0064	-1.7936
Adjusted R^2	0.9948		0.9036		0.9854	
S.E. of regression	0.0171		0.0135		0.0061	
Durbin-Watson statistic	2.4939		1.5078		2.2991	
Time Series structure	ARMA (18,24)		ARMA (3,16)		ARMA (1,6)	
Observations	300		280		160	

Data source: Own calculations from Industrial Survey; INEGI. Fixed effects weighted ordinary least squares estimation

Table 5. Autocorrelation tests: Mexican CQP at branch level

First degree autocorrelation	**Industrial survey: 1994 - 2003**	**Industrial survey: 2003-2009**	**Industrial survey: 2009-2012**
Durbin-Watson statistic	2.4939	1.5078	2.2991
Lower Limit (Du)	1.2162	1.4450	1.3450
Upper Limit (4-Du)	2.7838	2.5550	2.6550
	Significance at 1%	**Significance at 1%**	**Significance at 1%**
Breusch-godfrey serial correlation	**Industrial survey: 1994 - 2003**	**Industrial survey: 2003-2009**	**Industrial survey: 2009-2012**
LM statistic	5.6513	1.8687	10.2208
Prob. Chi-square	0.0593	0.3928	0.0260
Degree of correlation	2nd-order	2nd-order	2nd-order
LM statistic	5.7576	2.6275	10.3535
Prob. Chi-square	0.1240	0.4527	0.0758
Degree of correlation	3rd-order	3rd-order	3rd-order
LM statistic	5.8290	8.1022	13.5822
Prob. Chi-square	0.2123	0.1115	0.1017
Degree of correlation	4th-order	4th-order	4th-order
LM statistic	6.8078	8.0732	18.6290
Prob. Chi-square	0.3390	0.2328	0.1435
Degree of correlation	6th-order	6th-order	6th-order
LM statistic	11.5296	16.4625	21.5199
Prob. Chi-square	0.4842	0.1710	0.1908
Degree of correlation	12th-order	12th-order	12th-order

Data source: Own calculations from Industrial Survey, INEGI

In order to frame the upside scenario, we used a VAR model that represented the correlations among the variables of equations 3 and 4. Our purpose was twofold: first, to analyze the specific relationships between fixed assets (f) Tobin's Q value and the investment/capital ratio, (I/K); second, to estimate impulse response functions using Cholesky decomposition. Such effects were applied to the period 2013-2018 to obtain the forecasted series of fixed assets. After that process we got the AAGR of fixed assets in such period and applied an additional 50% increase of AAGR starting 2019 up to 2022. The rationale of the last formulation follows the expected impact of the Energy reform in CQP[2]. Commonly, the construction of new petrochemical plants or additional production capacity of CQP in Mexico has lasted between seven to four years after investment in the oil sector has taken place. Therefore, we assume that CQP will react in the same rate that primary oil activities will do driven by the new Energy laws.

Downside scenario assumes no additional investment in CQP takes place to increase production capacity. In other words, CQP does not react positively to the Energy Reform. Instead, petrochemical imports increase. In order to build this scenario, we forecasted petrochemical imports using an ARMA (1,1) model since imports in CQP, and not trade balance, statistically cause gross expenditure in fixed assets. Then, annual increases in CQP imports were expected to subtract investment expenditure in the same rate. Table 6 shows the growth assumptions of all scenarios in terms of fixed assets.

Assumptions of the rest of the variables in equations 3 and 4 are the following. Net value of securities (V) is expected to follow the same pattern of gross expenditure in fixed assets (f) in each of the cases. Price of capital (p) is explained by an ARMA (7,1) model. Since the stock of capital (K) increases as the flow of capital or additional expenditure in fixed assets increases, then the cost of capital (pK) follows the behavior of (f) but adjusted by inflation of capital goods. Tobin's Q can be automatically computed given such assumptions.

In terms of the profits function, value of sales (s) is expected to follow the behavior of (f) but lagged two years, as causality test suggested in the previous section. The cost of depreciation (dep) is forecasted according to the level of (K)

[2] On August 2014, both Round 0 and 1 were announced by Government entities. They expressed that the additional flow of investment expenditure for oil extraction is estimated to be around $12.6 billion pesos annually, including PEMEX's farm-outs. This represents a 50% increase to current investment in the sector starting 2015.

assuming that the proportion (dep/K) during 1994-2012 remains the same in the future. In the case of labor costs (w) the rationale is the following: in 2013, wages in CQP increased in the same rate that minimum wage grew in the economy. Since Fiscal reform came into action in 2014, we applied the 14% overall increased in labor costs that the reform added to the private sector in that year. Finally, we applied a 4.6% increase annually to the period 2015-2022 assuming that wages in CQP increased in the same amount that minimum wage increased in 2015. We assume no additional rises in labor costs due to fiscal changes in the period 2016-2022.

The costs of intermediate inputs (inp) were forecasted using an ARMA (2,7) model. Growth rates from such estimation resulted similar to core CPI inflation levels predicted by the Bank of Mexico. On the other hand, the costs of raw materials (r) were estimated using an ARMA (8,1) model. Given all the assumptions, gross profit function (π) was estimated for each of the forecast scenarios. Finally, the uncertainty variable given by the profits variance (var (π)) could be computed for each of the cases.

Equations 3 and 4 were projected for the next ten years, that is, from 2013 to 2022. These projections use assumptions about the path of the determinants of CQP investment that have been outlined above. The projections are listed in Table 7 and plotted in Fig. 1.

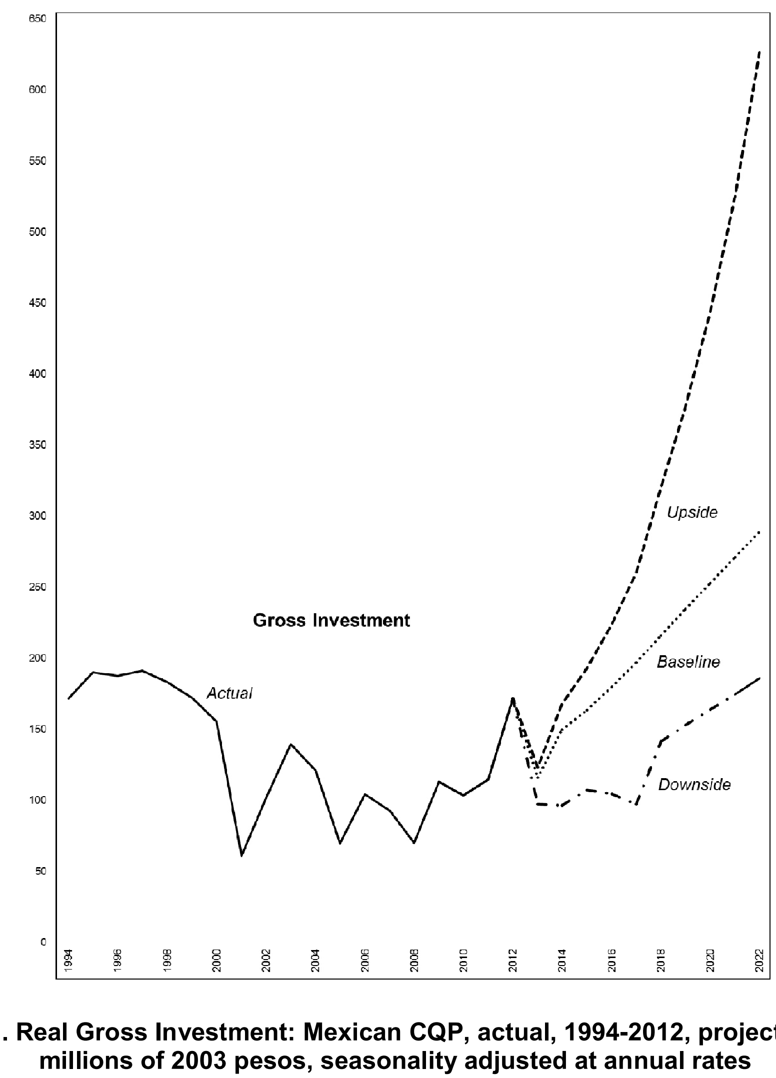

Fig. 1. Real Gross Investment: Mexican CQP, actual, 1994-2012, projected, 2013-2022 millions of 2003 pesos, seasonality adjusted at annual rates

Sources: 1994-2012, Industrial Survey, INEGI. 2013-2022, Author's estimates

Table 6. Expenditure assumptions of forecast scenarios: Mexican CQP, 2013-222

		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gross Expenditure in Fixed Assets, f (annual growth rate)	Upside	10.8%	8.8%	12.3%	16.3%	12.8%	13.8%	15.8%	15.8%	15.8%	15.8%
	Baseline	-2.2%	-2.2%	-2.2%	-2.2%	-2.2%	-2.2%	-2.2%	-2.2%	-2.2%	-2.2%
	Downside	-7.6%	-6.6%	-6.4%	-6.2%	-6.0%	-5.8%	-5.6%	-5.5%	-5.3%	-5.1%

Own calculations

Table 7. Projections of real gross investment using specified assumptions: Mexican CQP, 2013-222

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Upside	155	229	284	335	440	555	746	987	1,291	1,686
Baseline	123	158	158	157	171	168	163	181	196	179
Downside	81	117	134	120	129	114	101	92	83	77

Own calculations. Millions of 2003 pesos, seasonally adjusted at annual rates

4. CONCLUSION

As initially stated, the aim of this paper is to model the investment process of the Mexican Chemical Petrochemical Complex. Based on the estimation results following Bo [2] approach, the main conclusions of this study are the following: first, Q Theory Model behaves pretty good to explain investment process in the Mexican CQP; second, Tobin's Q doesn't carry all the relevant information to a firm's investment decisions. Even though it is a very important factor of the investment process; since every percent change of Q investment increases between 2% to 5%; third, uncertainty negatively affects CQP investment from -0.6% to -2% for one percent change in gross profit.

Uncertainty variable improves Q Model performance as well as Bo [2] has proved. Another source of improvement has been the recognition of the delay in investment spending as many investment researchers had applied, Jorgenson and Stephenson [39], Eisner [40], and Anderson [41].

These findings are useful for economic policy designers because the model's performance gives several clues about investment decisions in the petrochemical cluster. Incentives to productive investment should be considered to improve cluster expansion.

Another consideration goes to market structure as to determine the investment is essential to know the distributions of future values of the marginal productivity of capital and price. For a monopoly there are asymmetries in the distributions because the irreversibility prevents divest when negative shocks occur and investment is lower for any loss. Caballero and Pindyck [42] delved into the impact of market structure and uncertainty on investment.The model states that under perfect competition all relevant information should affect investment through Q. Even though the CQP has an oligopolistic market structure the Q Model has a good performance. Our attempt has been only in the empirical evidence level not the theoretical one.

As it has been set, our empirical test covers a sample of 740 observations from 1994 to 2012 arranged as panels of data. CQP has deepened its dependence on imported inputs during the period of analysis so the new Energy Reform could take along an important structural change within the cluster. Hence, the projections that have been made here may not implicitly capture this important needed change. However, under the conditions set out to model different scenarios fall seen in the first few years later to reverse that trend growth is sustained only in inertial and optimistic scenarios. It is important to notice that two of the three scenarios showed a moderate average growth of investment in the CQP: 30% in the optimistic, 5% on the baseline and 0.8% under the pessimistic. The optimistic scenario reflects the business euphoria associated to the Energy Reform. We recognize a deeper work to analyze the probabilities of the scenarios and the occurrence of a profound transformation in industry is needed. That transformation in the absence of an industrial policy and a huge change in the weight of western industry production will be very interesting to analyze. This theme could be another research topic in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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