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The impact of screen digitization on ticket sales: the case of Argentine cinemas

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Abstract

The late 2000's were a period of major technological innovation in the cinematographic industry, since digitization affected the entire value chain, ranging from production to distribution and exhibition activities. This paper focuses on the effect of digitization on exhibition by studying the impact of digitizing a screen on ticket sales. I perform a difference-in-differences estimation, exploiting the fact that not all screens were digitized simultaneously. Variability along time and between screens allows us to identify a causal effect. I find that digitized screens sell on average 22.2% more tickets. Furthermore, this effect was mostly attributable to 3D screens, given that 2D screens did not have a statistically significant effect on ticket sales.

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I. Introduction

The relationship between economic growth and technological innovation is almost a fact in economic thought, in spite of discussions regarding the direction of causality. As Segerstrom (1991, p. 807) states: “Economic growth is fuelled by both innovation and imitation”.

In the motion picture industry there has been a major technological change in the 21st century: the digitization. The Oxford Dictionary defines “to digitize” as to “convert (pictures or sound) into a digital form that can be processed by a computer”[2]. The impact of digitization has been huge, as it has affected the entire value chain of the cinematographic industry. According to Belton (2012, p. 187), “the term ‘digital cinema’ refers to more than just motion picture imaging, special effects or editing. It’s a term that properly encompasses the digitization of each aspect of the filmmaking chain from production […] to distribution and exhibition (projection)”.

The value chain in this industry comprises three stages: production, distribution and exhibition (Zhu, 2001). It should be noted that each stage is performed by different agents: the production is usually led by big studios or independent filmmakers, the distribution is made by companies that buy movies’ rights and finally resell them to the cinemas (exhibitors) in exchange for a percentage of their box office.

Digitization represents an innovation in both process and product, where *product* is the output and the *process* is the means by which the output is obtained (Orlikowski, 1991). Since movies must be processed by computers, the filmmaking process has suffered important technical changes[3], which have made the editing process simpler. Distribution has also been subject of improvements. The fact that movies are now transported in hard disks instead of 35mm rolls makes distribution a lot easier and cheaper. There is no doubt that digitization as a process innovation driver has resulted in huge cost savings (Mateer, 2014).

As opposed to the previous common agreement, there is a strong discussion as to whether digital cinema is indeed a product innovation or not. Belton (2012) affirms that digital cinema lacks novelty for audiences, while others, like Mendiburu (2009), compare the evolution from 35mm film projection to digital cinema to what color and

[2] Even though “digitalization” specifically refers to the use of computers in everyday life, I will use it as a synonym for “digitization”.
[3] For a complete description of these changes, see Mendiburu (2009).

sound meant to movies at their time. This discussion gains relevance due to the fact that exhibitors were “forced” to digitize their screens in order to remain in business: late into the 2000’s, major Hollywood producers announced that by mid 2010’s they would stop providing movies in the classic 35mm film format in order to only provide movies in digital format. This basically left exhibitors with two choices: they could either digitize or perish (Dombrowski, 2012).

In this paper I empirically address the question “what is the impact of digitizing screens on ticket sales?” In order to do so, I use a data set with information for all the cinemas in Argentina between 2007 and 2014 and I perform a difference-in-differences estimation. One characteristic of the digitization process that allows the difference-in-differences proper identification is that cinemas digitized their screens in phases and not all of them at once, which resulted in cinemas having simultaneously digitized and non-digitized screens during a given period.

The paper is organized as follows: Section II describes the data and explains the identification strategy, Section III presents the results and Section IV concludes.

II. Data and identification strategy

Data

The data panel consists of 1137 screens from Argentina comprising the period 2007-2014. The database includes daily information per screen for the number of tickets sold, its revenue, movies projected and their format (35mm, 2D or 3D). This information was taken from the Argentine firm Ultracine[4]. Table 1 shows some summary statistics. In total, 1,901,176 observations are available for estimation.

During the concerning period, Argentine movie theaters digitalized their screens at different points in time. Table 2 shows that even at a very aggregate (province - year) level there is both cross-section and time series variability.

Identification strategy

The purpose of this paper is to identify the average effect of digitalizing a screen on its ticket sales, by comparing sales in digitized and non-digitized screens. Since this is not an experiment, it is not possible to guarantee that digitalization was random.

[4]Ultracine, available online at: www.ultracine.com. Last access on 5/8/2015.

There may have been different particular characteristics in some screens that influenced the decision of which ones to digitalize. For example, screens belonging to large movie theater chains may have been digitalized before, given that these chains had more funding resources at their disposal. If this were the case, it would pose a serious threat to the correct identification of the parameter of interest. Fortunately, it is possible to argue that these factors, which could bias our estimation, are different across screens but remain constant along time. This is the reason why the use of panel data is so convenient: it allows us to estimate a difference-in-differences model to control for time invariant unobservable variables. This model compares the changes in the outcomes of the treated group (digitized screens) to the changes in the outcomes of the control group (non-digitized screens). Hence, the evolution of the ticket sales of non-digitized screens is used as a counter-factual. Formally, the model can be expressed as:

$$\ln(Tickets)_{it} = \beta Digitalized_{it} + \alpha_i + \mu_t + \phi Movie_{it} + \delta AveragePrice_{it} + \varepsilon_{it} \quad (1)$$

where $ln(Tickets)_{it}$ is the natural logarithm of tickets sold by screen i in day t; $Digitalized_{it}$ is a dummy variable that takes value one if the screen i projected a 2D or 3D movie on that day (meaning it was digitalized, since non-digitalized screens cannot project those formats) and zero otherwise; $Movie_{it}$ is a vector of movie dummy variables that equal one if movie j was projected on screen i on day t; $AveragePrice_{it}$ is calculated as the revenue of screen i on day t divided by ticket sales of that screen on that day; α_i is a screen fixed effect and μ_t is a time fixed effect.

ε_{it} is a screen time-varying error which is generally assumed to be non-serially cross correlated (i.e, independent across time and space). However, I perform a panel data analysis, which means errors could have some kind of correlation among them. For instance, errors could be correlated across time for the same screen. If the correlation happened to be positive, the robust standard errors computed by the model would underestimate the real standard errors and the null hypothesis would be over rejected. To address this problem, standard errors are clustered at three different levels: (a) same screen along time, (b) same cinema along time and (c) same area along time, where area implies neighborhoods in big cities (e.g., Belgrano or Once in Capital Federal) and towns in the case of less populated provinces (e.g., Rafaela or Venado Tuerto in the state of Santa Fe). Any arbitrary covariance structure is allowed at every level. It is important to emphasize that if errors are highly correlated, clustering them may reduce the estimation's statistical power[5].

The coefficient of interest is β, which is the average effect of digitalization on ticket sales. The identification assumption is that the evolution of tickets sold in non-digitalized screens is an unbiased estimator of how many tickets would have been sold for the eventually digitalized screens in the absence of digitization. The problem is that this assumption cannot be tested. Nonetheless, it is possible to compare the trends of both groups before the treatment. If they are similar before the treatment, it is more plausible to assert that they would be similar afterwards.

The first way to compare pre-treatment trends is to check the linear trend. In Table 3, the linear trend is tested with the interaction between the time variable and the dummy variable *EventuallyDigitalized,* which equals one if the screen will be eventually digitalized and zero otherwise. This interaction captures the difference in linear trends between the treatment and the control group. I find that the null hypothesis (pre-treatment linear trends are equal) cannot be rejected. This does not mean that they are equal; it just means that there is not enough evidence to reject the null hypothesis that they are equal.

The second method I use to test if pre-treatment trends are equal is a graphical one. In Figure 1 the reader can see that even though the groups are not equal in levels, they are very similar in trends. Thus, it is important to note that the dependent variable is in logarithms and not in levels when the effect is estimated. Therefore, the comparison is made between the percentage change in ticket sales for each group, and not the absolute change.

In conclusion, since both previous results suggest that digitalized and non-digitalized screens had equal trends in the pre-digitalization period, the difference-in-differences approach will be taken as valid.

[5] See Bertrand *et al.* (2004).

III. Results

Tables 4a and 4b show the main results[6]. Column 1 in Table 4a shows the results of a model that includes only the digitalization dummy and fixed effects for each screen and day. In this case, digitized screens experienced an average 11.8% increase in their daily ticket sales.

In Table 4a, as movie fixed effects and average price are included, we can see that the digitalization dummy increases. In column 4, which controls for both the average price and the movies projected, the average increase in ticket sales for digitalized screens is 22.2%. This suggests that there is a positive correlation between the controls and the treatment, since their omission biases the coefficient downward.[7] It should be noted that the estimation of the average effect is always significant at 1% level, in spite of the presence of positive correlation among the errors.

In Table 4b, the average effect of 2D and 3D is assessed. Here, it is interesting to see how the 2D parameter decreases as controls are included and loses statistical significance as standard errors are clustered, while the average effect of 3D increases with the inclusion of controls and remains significant at 1% despite the clustering of standard errors. In column 4, which includes average price and day, screen and movie fixed effects, the average increase in ticket sales for 3D screens is 27.1%.

Finally, I perform a few robustness checks to assess whether the previous results are valid when the number of observations decreases and the estimation loses statistical power. In Table 5a, I replicate column 4 of Table 4a but with data collapsed at the screen-week and screen-month level instead, while in Table 5b I replicate column 4 of Table 4b with data collapsed at those same levels.

In Table 5a, the average effect of digitalization remains around 18% (18.9% for weekly data and 17.7% for monthly data), while in Table 5b the average effect stays around 19% for 3D (20% for weekly data and 18.2% for monthly data). The same loss of significance occurs for the average effect of 2D in Table 5b when clustering standard errors.

[6] Computing regressions with high and multidimensional fixed effects with standard STATA commands is nearly impossible due to hardware restrictions. To solve this problem, the command "reghdfe" was used. For more information, see Guimaraes and Portugal (2010).

[7] Remember the formula for biases caused by omission of relevant variables:
$\hat{\beta}_1 = \beta_1 + (X_1^{'}X_1)^{-1}X_1^{'}X_2\beta_2$.

Taking everything into account, results suggest that digitalized screens increased ticket sales. Additionally, the increase was mostly driven by 3D screens given that 2D screens did not have a statistically significant effect[8]. This could be explained by the positively valued, more real and vivid experience 3D screens offer to spectators (Rooney and Hennessy, 2014).

IV. Conclusions

Digitization is claimed to be a major innovation both in process and in product for the cinematographic industry. Previous literature considers it is primarily an innovation in process since it substantially reduces costs in the stages of production and distribution. The issue that remains under discussion is whether it is a product innovation or not. Throughout this paper I addressed this matter empirically and the identification strategy allows us to state that the effect of digitization on ticket sales is causal due to the fact that the pre-treatment trends of tickets sold for digitized and non-digitized screens are very similar. Besides, our estimation is robust, even when collapsing date at more aggregate levels.

I arrived at two main results: (1) digitized screens sell on average 22.2% more tickets than non-digitized screens; (2) 3D movies sell on average 27.1% more tickets and the effect of 2D movies is not different from zero, in a statistical sense, suggesting that 3D movies possess a novelty value for the audience, as opposed to 2D movies.

I would like to highlight that, if the total amount of tickets sold in Argentina had remained constant during the period under analysis, the impact of digitized screens on ticket sales would have only reflected a composition effect. That is, digitized screens would have "stolen" spectators from non-digitized screens and there would not be an increase in total sales. In Figure 2, the reader can see that the amount of tickets sold in Argentina did vary between 2007 and 2014. Thus, we are able to state that the effect found in this paper is not just a composition effect.

There are a number of mechanisms worth exploring, other than the improvement in quality, which could explain why digitized screens sell more tickets than the non-digitized ones. One of these is the fact that digitization helps fighting digital piracy and illegal downloads. The first way to verify this is to look for data to see if, in areas with

[8] All these results also hold when the regression is performed on $Tickets_{it}$ instead of $ln(Tickets)_{it}$, and are available upon request.

more digitized screens, there are less illegal downloads[9]. A second, indirect way consists of checking whether the time that goes by between a movie's *avant premiere* in its country of origin and the moment in which such movie is projected for the first time in another country diminishes for digitized movies. If that happened, cinemas would be winning the time battle against digital pirates.

[9] This data can be obtained from servers like Torrent. See www.utorrent.com.

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Table 1. Summary Statistics

	Mean	Standard Deviation
Tickets	155.7	201.27
Revenue	3808.43	6352.9
Average price	21.87	13.06

Note: The total number of observations for *Tickets* and *Revenue* is 2,020,403 and for *Average Price* is 1,901,176.

Table 2. Cross-section and time series variability of Digitalized

Zone	Year							
	2007	2008	2009	2010	2011	2012	2013	2014
BUENOS AIRES	0	0	1	1	1	1	1	1
CAPITAL FEDERAL	0	1	1	1	1	1	1	1
CATAMARCA	0	0	0	1	1	1	1	1
CHACO	0	0	0	1	1	1	1	1
CHUBUT	0	0	0	0	1	1	1	1
CORDOBA	0	1	1	1	1	1	1	1
CORRIENTES	0	0	0	1	1	1	1	1
ENTRE RIOS	0	0	0	0	1	1	1	1
FORMOSA	0	0	0	0	0	1	1	1
GRAN BUENOS AIRES	0	1	1	1	1	1	1	1
JUJUY	0	0	0	1	1	1	1	1
LA PAMPA	0	0	0	0	1	1	1	1
LA RIOJA	0	0			0	1	1	1
MENDOZA	0	0	1	1	1	1	1	1
MISIONES	0	0	0	0	1	1	1	1
NEUQUEN	0	0	1	1	1	1	1	1
RIO NEGRO	0	0	0	0	1	1	1	1
SALTA	0	0	1	1	1	1	1	1
SAN JUAN	0	0	0	1	1	1	1	1
SAN LUIS	0	0	0	1	1	1	1	1
SANTA CRUZ	0	0	0	0	1	1	1	1
SANTA FE	0	0	1	1	1	1	1	1
SANTIAGO DEL ESTERO	0	0	1	1	1	1	1	1
TIERRA DEL FUEGO	0	0	1	1	1	1	1	1
TUCUMAN	0	0	1	1	1	1	1	1

Note: "1" means that there was at least one digitalized screen in the Zone in that year. "0" means that there was not.

Table 3. Pre Treatment Trends equality test

	Tickets (1)
Time	-0.045
	(0.006)***
EventuallyDigitalized*Time	0.006
	(0.008)
Observations	479,304
R-squared	0.002

Notes: Robust standard errors are in parentheses. The model includes a screen dummy and is estimated by OLS. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

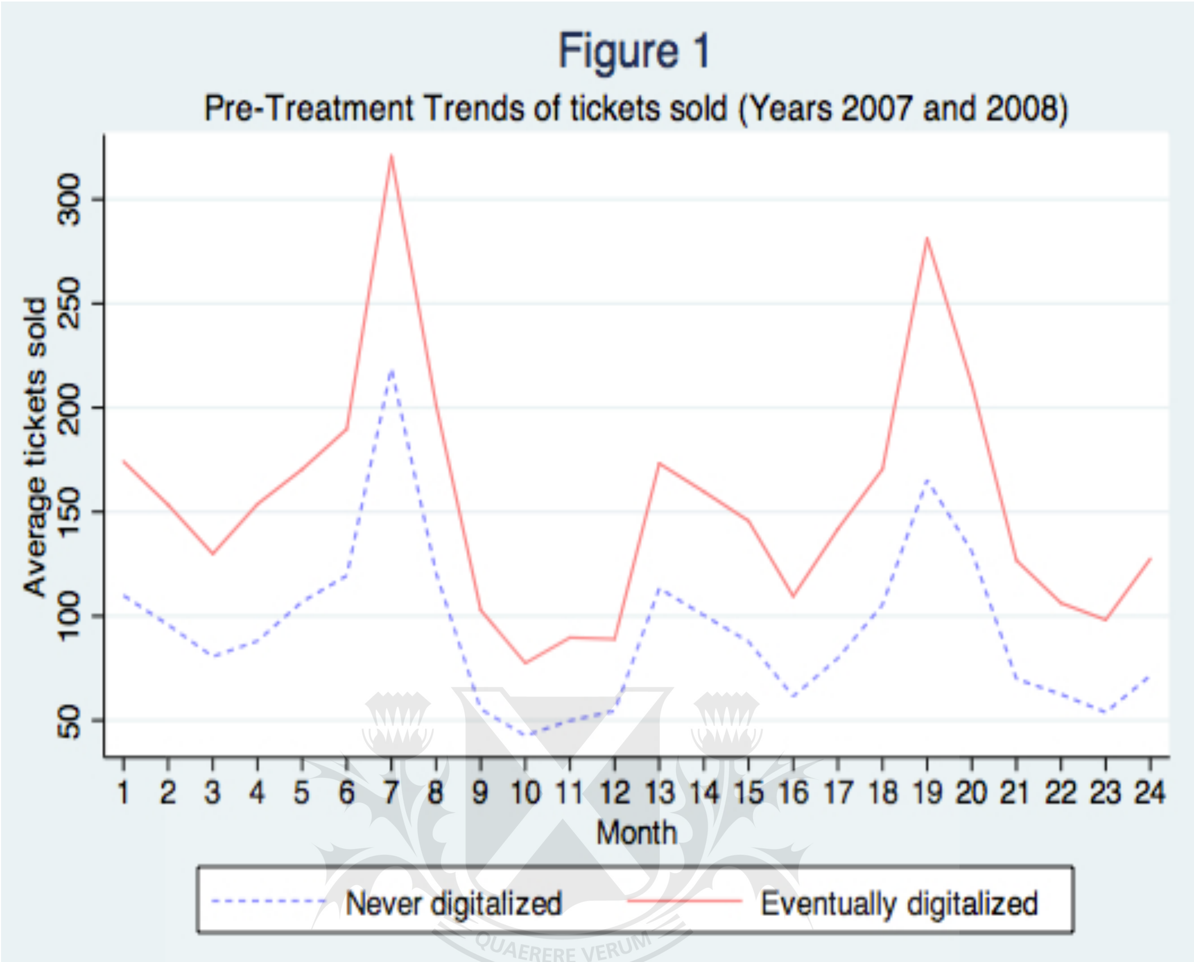

Figure 1
Pre-Treatment Trends of tickets sold (Years 2007 and 2008)
Average tickets sold
50
100
150
200
250
300
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Month
Never digitalized
Eventually digitalized

Table 4a. The effect of digitalization on ticket sales

	ln(Tickets)			
	(1)	(2)	(3)	(4)
Digitalized	0.118 (0.002)*** [0.017]*** {0.029}*** <0.032>***	0.138 (0.002)*** [0.016]*** {0.025}*** <0.026>***	0.203 (0.002)*** [0.017]*** {0.030}*** <0.032>***	0.222 (0.002)*** [0.016]*** {0.027}*** <0.027>***
Average price			-0.017 (0.000)*** [0.001]*** {0.002}*** <0.002>***	-0.018 (0.000)*** [0.001]*** {0.002}*** <0.002>***
Observations	1,901,176	1,901,176	1,901,176	1,901,176
R-squared	0.639	0.708	0.642	0.712
¿Movie Fixed effects?	No	Yes	No	Yes

Notes: Robust Standard errors are in parentheses. Clustered standard errors at screen level are in square brackets. Clustered standard errors at cinema level are in braces. Clustered standard errors at area level are in angle brackets. All models include a screen dummy and a day dummy and are estimated by OLS. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Table 4b. The effect of digitalization on ticket sales

	ln(Tickets)			
	(1)	(2)	(3)	(4)
2D	0.041	0.045	0.005	0.012
	(0.002)***	(0.002)***	(0.002)**	(0.002)***
	[0.011]***	[0.011]***	[0.012]	[0.011]
	{0.021}**	{0.021}**	{0.022}	{0.022}
	<0.019>**	<0.019>**	<0.021>	<0.019>
3D	0.101	0.107	0.259	0.271
	(0.002)***	(0.002)***	(0.002)***	(0.003)***
	[0.019]***	[0.019]***	[0.020]***	[0.021]***
	{0.028}***	{0.025}***	{0.030}***	{0.028}***
	<0.036>***	<0.032>***	<0.034>***	<0.029>***
Average price			-0.020	-0.020
			(0.000)***	(0.000)***
			[0.001]***	[0.001]***
			{0.002}***	{0.002}***
			<0.002>***	<0.002>***
Observations	1,901,176	1,901,176	1,901,176	1,901,176
R-squared	0.638	0.708	0.643	0.712
¿Movie Fixed effects?	No	Yes	No	Yes

Notes: Robust Standard errors are in parentheses. Clustered standard errors at screen level are in square brackets. Clustered standard errors at cinema level are in braces. Clustered standard errors at area level are in angle brackets. All models include a screen dummy and a day dummy and are estimated by OLS. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Table 5a. Robustness check

	ln(Tickets)	
	(1)	(2)
Digitalized	0.189	0.177
	(0.004)***	(0.008)***
	[0.016]***	[0.016]***
	{0.028}***	{0.026}***
	<0.030>***	<0.028>***
Average price	-0.004	-0.005
	(0.000)***	(0.001)***
	[0.001]***	[0.002]***
	{0.002}***	{0.002}***
	<0.002>***	<0.002>***
Observations	290,627	70,078
R-squared	0.722	0.818
¿Movie Fixed effects?	Yes	Yes

Notes: Robust Standard errors are in parentheses. Clustered standard errors at screen level are in square brackets. Clustered standard errors at cinema level are in braces. Clustered standard errors at area level are in angle brackets. Model (1) uses data collapsed at week level, while model (2) uses data collapsed at month level. All models include a screen dummy and a day dummy and are estimated by OLS. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Table 5b. Robustness check

	ln(Tickets)	
	(1)	(2)
2D	0.029	0.028
	(0.004)***	(0.008)***
	[0.011]**	[0.012]**
	{0.019}	{0.019}
	<0.018>	<0.019>
3D	0.200	0.182
	(0.005)***	(0.010)***
	[0.020]***	[0.021]***
	{0.029}***	{0.029}***
	<0.034>***	<0.031>**
Average price	-0.006	-0.006
	(0.000)***	(0.001)***
	[0.001]***	[0.002]***
	{0.002}***	{0.002}***
	<0.002>***	<0.002>***
Observations	290,627	70,078
R-squared	0.722	0.818
Movie Fixed effects	Yes	Yes

Notes: Robust Standard errors are in parentheses. Clustered standard errors at screen level are in square brackets. Clustered standard errors at cinema level are in braces. Clustered standard errors at area level are in angle brackets. Model (1) uses collapsed data at week level, while model (2) uses data collapsed at month level. All models include a screen dummy and a day dummy and are estimated by OLS. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

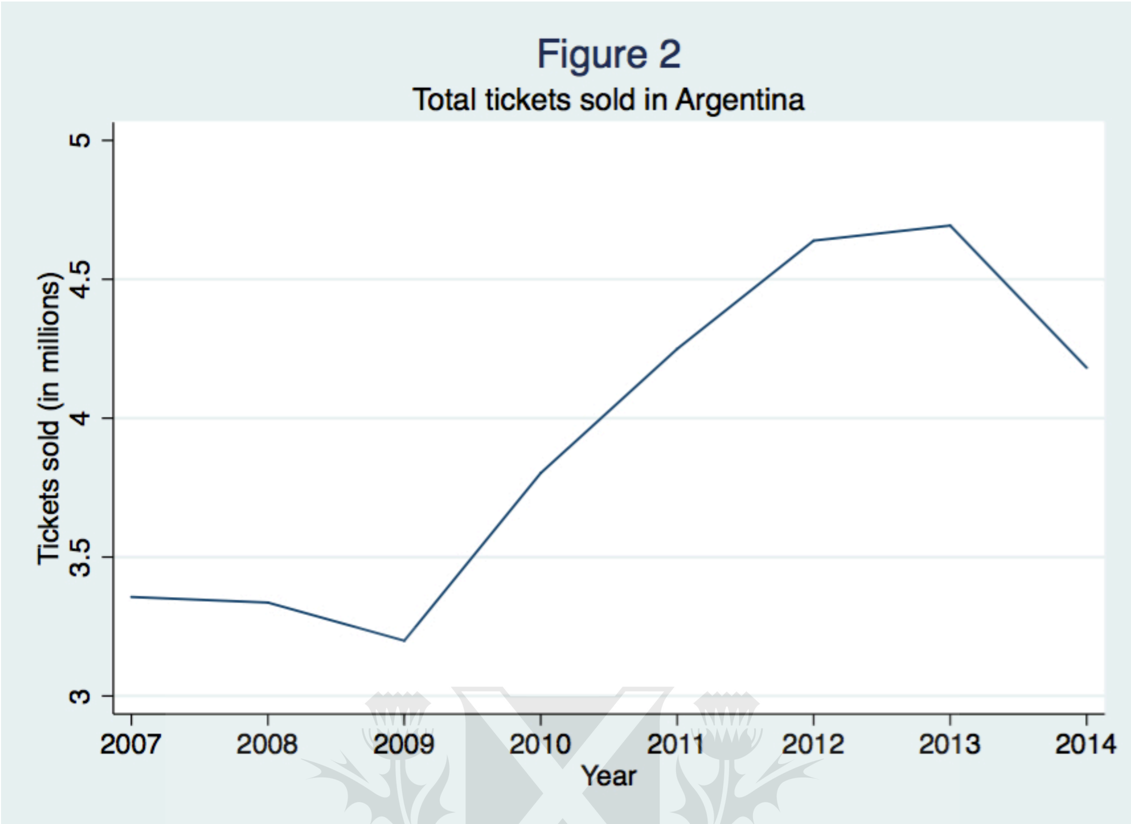
Figure 2
Total tickets sold in Argentina
Tickets sold (in millions)
5
4.5
4
3.5
3
2007
2008
2009
2010
2011
2012
2013
2014
Year