Who has won the Rugby Union World Cup, and why ?

A fundamentals-based empirical analysis of past outcomes in an international team-based sequential elimination tournament.

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joint with Brian O'Rourke

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Roadmap

Structure of the presentation

- Introduction
- RUWC 2015
- Probability tree
- Empirical model
- Specification
- Stata command
- Conclusion
- References

Rugby Union World Cup Tournament

History

- **First held in 1987** co-hosted by New Zealand and Australia
- The winners are awarded the **William Webb Ellis Cup**. "In 1823, William Webb Ellis **first picked up the ball in his arms and ran** with it. And for the **next 156 years forwards have been trying to work out why**." – Sir Tasker Watkins (1979)
- **Australia, New Zealand,** and **South Africa** have won the title **twice** while **England once**.
- Sixteen teams were invited to participate in the inaugural tournament in 1987. **Since 1999 twenty teams have taken part**.
- **England will host the 2015 World Cup**, while Japan will host the event in 2019.
- The current format allows for twelve of the twenty available positions to be filled by automatic qualification, as the **teams who finish third or better in the pools stages qualify for the subsequent** edition

Rugby Union World Cup Tournament

Past world cup Facts

- There have only been **7 Rugby World Cup so far**
- The **2003** Rugby World Cup had a global **cumulative audience** of **3.5 billion**, and was **broadcast in 205 countries** around the world.
- **No team has won Tri-Nations** tournament and a **Rugby World Cup** in the **same year**
- **Winners** of 5 or **6 Nations** tournaments **have reached the semi finals at least** of the Rugby World Cup happened in the same year.
- **Ireland is the only host nation** which has **not reached the semi finals** of World Cup

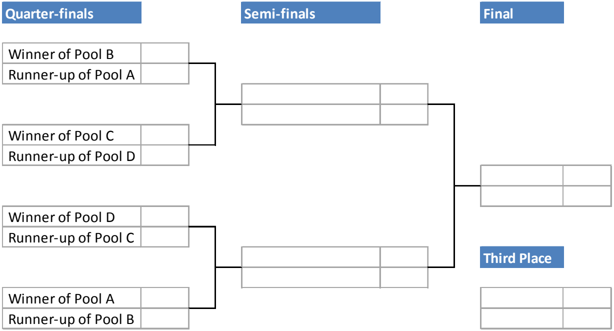
England 2015

- Global television is expected to reach over **4 billion people**.
- Potential **economic impact** to the UK of approx **£2.1 billion**
- **13 venues** in **11 cities**

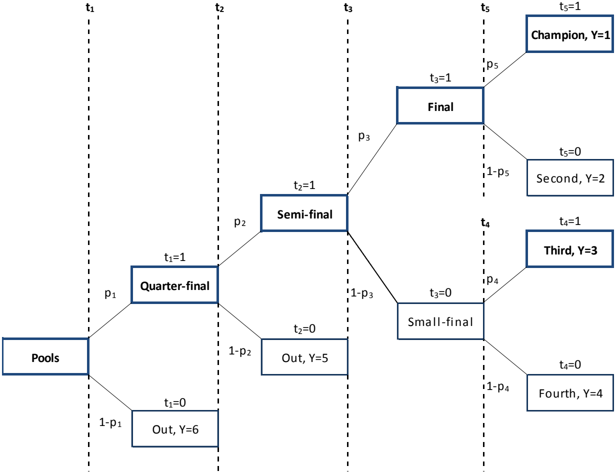
Rugby Union World Cup Tournament

England 2015

Pool A	Pool B	Pool C	Pool D
Australia	South Africa	New Zealand	France
England	Samoa	Argentina	Ireland
Wales	Scotland	Tonga	Italy
Fiji	Japan	Georgia	Canada
Uruguay	United States	Namibia	Romania



Probability tree for a country/year



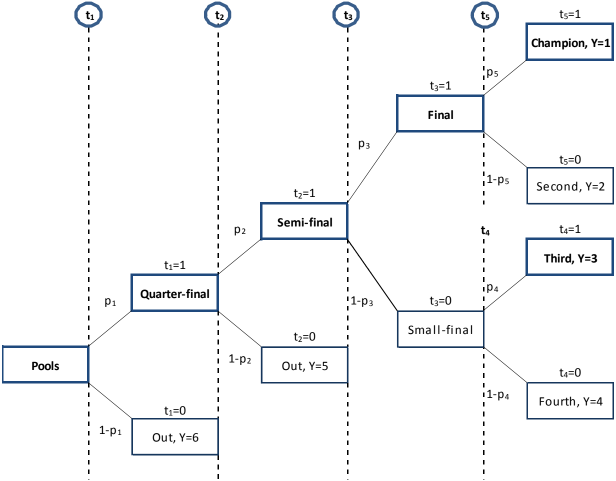
Probability tree

Definitions

- t_j **is the transition indicator from stage** $j-1$ **to stage** j**. It will be** 1 **in case of success and** 0 **otherwise.**
- p_j is the probability of transition from stage $j-1$ to stage j,i.e. $P(t_j = 1 | \textit{sequence to reach } j-1)$
- Y is the outcome variable, $Y \in \{1, 2, 3, 4, 5, 6\}$
- i is the country indicator
- t is the time indicator
- *Pools* indicates the pool stage, *QF* quarter-finals, *SF* semi-finals, *F* the final, *FT* the final for the third place, *T* the third place and *W* winning of the tournament

Probability tree

Probability tree for a country/year



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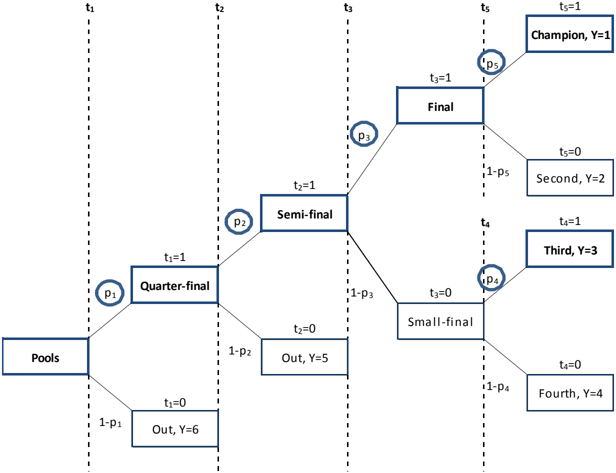

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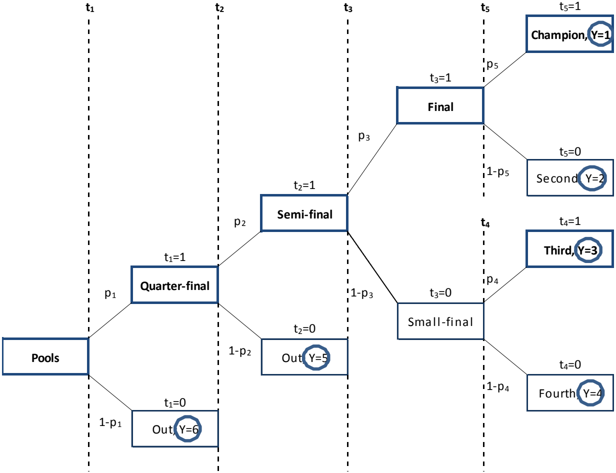


Probability tree

Probability of outcomes

- $P(Y=6)=P(t_1=0)$
- $P(Y=5)=P(t_1=1, t_2=0)$
- $P(Y=4)=P(t_1=1, t_2=1, t_3=0, t_4=0)$
- *etc...*

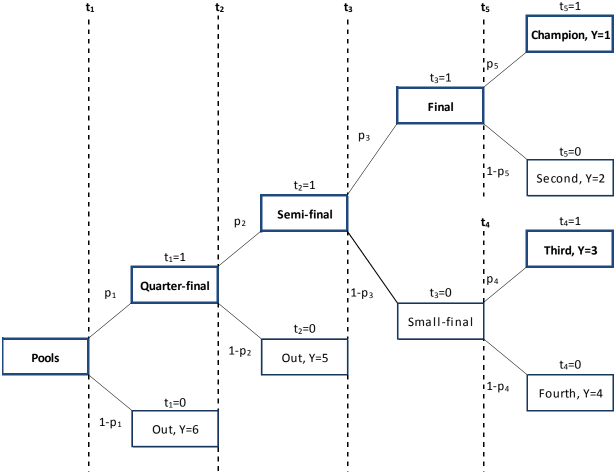
Probability of reaching given stages

- $P(QF)=P(t_1=1)$
- $P(SF)=P(t_1=1, t_2=1)$
- $P(F)=P(t_1=1, t_2=1, t_3=1)$
- *etc...*

Transition probabilities

- $P(SF|QF)=\frac{P(SF\cap QF)}{P(QF)}=\frac{P(SF)}{P(QF)}=\frac{P(t_1=1,t_2=1)}{P(t_1=1)}$
- $P(F|SF)=\frac{P(F\cap SF)}{P(SF)}=\frac{P(F)}{P(SF)}=\frac{P(t_1=1,t_2=1,t_3=1)}{P(t_1=1,t_2=1)}$
- *etc...*

Probability tree for a country/year



Empirical model

Probability of outcomes

We assume that success in each stage j for individual i at time t is associated to a latent variable $t^*_{j,i,t}$ such that

$$\begin{cases} t_{j,i,t} = 0 & \text{if} \quad t^*_{j,i,t} \leq 0 \\ t_{j,i,t} = 1 & \text{if} \quad t^*_{j,i,t} > 0 \end{cases}$$

We model the latent variable by $t^*_{j,i,t} = x'_{i,t}\beta_j + \varepsilon_{j,i,t}$; $i \in N_j$ where:

- $x'_{i,t}$ is the vector of **explanatory variables**. Here we assume the variables are the same for all stages
- β_j is the vector of **parameters** to be estimated at stage j
- $\varepsilon_{j,i,t}$ are the **unobservables** for stage j. They are assumed to be multivariate normally distributed with mean zeros and covariance Σ
- N_j is the set of **individuals still at risk** (i.e. still in the competition) at stage j.

Empirical model

Probability of outcomes (individual i, period t)

- $P(Y_{it} = 6) = P(t_{1it} = 0) = P\left(\varepsilon_{1it} \leq -x'_{it}\beta_1\right)$
- $P(Y_{it} = 5) = P(t_{1it} = 1, t_{2it} = 0) =$
  $P\left(\varepsilon_{1it} > -x'_{it}\beta_{it}, \varepsilon_{2it} \leq -x'_{it}\beta_2\right)$
- *etc* ...

Probability of reaching given stages (individual i, period t)

- $P(QF_{it}) = P(t_{1it} = 1) = P\left(\varepsilon_{1it} > -x'_{1it}\beta_1\right)$
- $P(SF_{it}) = P(t_{1it} = 1, t_{2it} = 1) =$
  $P\left(\varepsilon_{1it} > -x'_{1it}\beta_1, \varepsilon_{2it} > -x_{2it}\beta_2\right)$
- *etc*...

Transition probability (individual i, period t)

- $P(SF_{it}|QF_{it}) = \frac{P(t_{1it}=1, t_{2it}=1)}{P(t_{1it}=1)} = \frac{P(\varepsilon_{1it}>-x'_{1it}\beta_1, \varepsilon_{2it}>-x_{2it}\beta_2)}{P(\varepsilon_{1it}>-x'_{1it}\beta_1)}$
- *etc* ...

Empirical model

Independence of the unobservables

- If the ε**s are independent**, the **joint probability is the product of the individual probabilities** and the model becomes a simultaneous estimation of probits of successes at each stages (considering only those individuals still at risk)
- This is assumption is **standard in sequential logit/probit** models
- Under this assumption the **likelihood function is easy to write**

Problems

- This simple procedure is however **unrealistic** in our setup as it is difficult to consider the unobservable variables to be **uncorrelated between stages**.
- Ignoring these correlations would most probably create **biases since the selection rules** of each stage would be neglected.

Empirical model

Solution

- Should tackle the problem from a **different perspective**
- We should start by estimating the **probability of reaching the 6 possible observed modalities** which is the same as the probability of observing specific sequences of successes and failures in transitions
- What we should estimate is $P(Y_{it} = k) = x'_{i,t}\beta_k + \varepsilon_{k,i,t}$ where $k \in \{1, 2, 3, 4, 5, 6\}$, $i = \{1, ..., 25\}$, $t = \{1987, 1991, ..., 2011\}$ using a **multinomial probit (asmprobit in Stata)**
- We should **then calculate the marginal effects associated to an expression**. For example $\frac{\partial(1-P(Y_{it}=6))}{\partial x_{\ell,i,t}}$ will tell us how the probability of going to the quarter-finals is affected by a change in the ℓ variable
- Would be easy to do using `expression`(*pnl_exp*) in **Stata 13 if post-estimation command** was available.
- Easy trick to have it

Empirical model

Was work in progress **mprobit2.ado,** bacame useless with **Stata 14**

- Calls on **asmprobit.ado** with only *casevar* with the desired correlation structure to estimate the parameters
- Saves the coefficients matrix and covariance matrix
- Quetly runs a standard **mprobit.ado** with only one iteration
- Reposts matrices b and V using the ones estimated in **asmprobit.ado**
- The **marginal effects** associated to the **desired expression** are now available. For example $\frac{\partial(1-P(Y_{it}=6))}{\partial x_{\ell,i,t}}$ will tell us how the probability of going to the quarter-finals is affected by a change in the ℓ variable
- For the illustration we assume independent latent variable errors (128 cases to estimate 104 parameters with unstructured correlation structure)

Model specification

Team Variables

- Percentage of **points scored** in the prior 4 years by foot
- Percentage **wins** in the prior 4 years
- Mean **scrum weight**
- Mean **second row height**
- Mean **number of caps**
- Mean **experience**
- **Debut** year
- WRU **ranking**

Model specification

Socio-economic Variables

- **Southern hemisphere** dummy
- Number of **affiliated** players
- Total **population**
- Percentage **land in geographical tropics**
- **Mortality rate**, infant (per 1,000 live births)
- **Arable land** (% of land area)
- Population ages **65 and above** (% of total)
- **GDP growth** (annual %)
- **GDP per capita** (constant 2005 US$)
- Percentage of **catholics in total population**

Results team variables

Marginal effects *(d(y)/d(lnx) for population and affiliated)*

	Outcome-Multinomial Probit					Level-Average marginal effect			
VARIABLES	1	2	3	4	5	Quarter	Semi	Final	Champion
Affiliated players	4.06e-05**	4.79e-05**	3.62e-05*	3.72e-05*	4.04e-05**	0.194*	0.068	0.103**	-0.006
	(2.06e-05)	(2.16e-05)	(2.07e-05)	(2.05e-05)	(2.05e-05)	(0.109)	(0.045)	(0.045)	(0.029)
Total Population	-8.29e-07**	-2.81e-07**	7.15e-08	1.20e-07***	-7.52e-08*	-0.078	-0.367	-0.991***	-0.824**
	(3.53e-07)	(1.11e-07)	(5.97e-08)	(3.87e-08)	(4.14e-08)	(0.574)	(0.233)	(0.315)	(0.344)
Percentage of points scored by foot (4 prior years)	15.68	-4.122	0.258	-8.777	-1.362	-0.127	0.196	0.563*	0.652**
	(9.854)	(6.101)	(7.191)	(7.484)	(3.839)	(0.271)	(0.332)	(0.312)	(0.290)
Percentage wins (4 prior years)	15.20*	40.69***	21.78**	30.36***	12.45***	1.057	0.877**	0.304	-0.176
	(8.370)	(9.939)	(10.10)	(10.25)	(4.620)	(0.695)	(0.402)	(0.230)	(0.209)
Mean scrum weight	0.465*	0.147	-0.357	0.371	0.136	0.008	0.002	0.016*	0.015**
	(0.248)	(0.175)	(0.218)	(0.292)	(0.103)	(0.007)	(0.009)	(0.009)	(0.007)
Mean second row height	12.59	-48.79***	35.12***	92.16***	-9.059*	0.154	2.135**	-1.680	-0.117
	(29.02)	(17.05)	(13.50)	(29.78)	(5.248)	(0.331)	(0.834)	(1.062)	(0.936)
Mean number of caps	-0.161*	0.114*	-0.256***	-0.223**	-0.0482	-0.005**	-0.008**	0.004	-0.002
	(0.0927)	(0.0671)	(0.0839)	(0.102)	(0.0338)	(0.002)	(0.003)	(0.003)	(0.003)
Debut	-2.080**	-0.231	-0.257***	-0.310***	-0.157***	-0.013***	-0.041***	-0.062**	-0.067**
	(0.858)	(0.184)	(0.0749)	(0.0877)	(0.0468)	(0.003)	(0.015)	(0.026)	(0.028)
Ranking	0.908**	-1.013***	0.522*	0.240	-0.0706	-0.000	0.024	0.003	0.031**
	(0.386)	(0.297)	(0.306)	(0.316)	(0.0996)	(0.007)	(0.035)	(0.014)	(0.014)
Pseudo-R^2			67.92%				67.92%		
Observations			128				128		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Coefficients associated to Affliliated and Population are semi-elasticities

Results country variables

Marginal effects

VARIABLES	Outcome-Multinomial Probit 1	2	3	4	5	Level-Average marginal effect Quarter	Semi	Final	Champion
Southern hemisphere	60.60***	56.56***	43.70***	56.01***	4.129	0.383***	0.555***	0.310*	0.147
	(16.23)	(11.39)	(9.634)	(15.48)	(2.911)	(0.052)	(0.054)	(0.178)	(0.105)
Percentage land in geographical tropics	-0.591	-22.70***	-22.74***	-29.44***	-10.51	-0.927*	-0.552*	0.460	0.616*
	(12.83)	(8.648)	(8.817)	(10.29)	(6.779)	(0.527)	(0.328)	(0.363)	(0.363)
Mortality rate, infant (per 1,000 live births)	-0.452*	-0.997**	-0.251	-1.303**	-0.334*	-0.029	-0.024**	-0.008	0.003
	(0.259)	(0.442)	(0.167)	(0.514)	(0.182)	(0.024)	(0.011)	(0.008)	(0.008)
Arable land (% of land area)	1.526***	1.705***	0.965***	1.701***	-0.223	0.005	0.094***	0.056***	0.035***
	(0.496)	(0.455)	(0.304)	(0.512)	(0.148)	(0.009)	(0.016)	(0.016)	(0.013)
Population ages 65 and above (% of total)	0.106	-0.446	1.576**	0.220	-0.233	-0.003	0.042	-0.023	-0.006
	(1.317)	(0.932)	(0.613)	(1.251)	(0.255)	(0.020)	(0.040)	(0.048)	(0.045)
GDP growth (annual %)	-0.841***	-0.252	-0.244	-0.641*	-0.162*	-0.015***	-0.023*	-0.018	-0.020*
	(0.324)	(0.229)	(0.167)	(0.343)	(0.0834)	(0.005)	(0.013)	(0.012)	(0.011)
GDP per capita (constant 2005 US$)	-3.60E-04	5.63E-04	-5.45e-05	2.08E-04	-1.40E-04	-0.000	0.000	0.000	-0.000
	(3.24e-04)	(2.16e-04)	(1.66e-04)	(1.63e-04)	(8.90e-05)	(0.000)	(0.000)	(0.000)	(0.000)
Percentage of catholics in total population	-0.371	-0.0637	-0.209**	-0.280***	-0.128*	-0.010*	-0.009*	-0.004	-0.007
	(0.273)	(0.0937)	(0.0873)	(0.107)	(0.0746)	(0.005)	(0.005)	(0.009)	(0.009)
Constant	3,787**	498.9	367.9***	306.4*	321.1***	-	-	-	-
	(1,617)	(346.2)	(140.2)	(166.4)	(99.43)				
Pseudo-R^2			67.92%				67.92%		
Observations			128				128		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Coefficients associated to Affliliated and Population are semi-elasticities

Illustrative example

Estimated result

A	B	C	D
Australia	**South Africa**	**New Zealand**	**France**
England	Scotland	Argentina	Ireland
Wales	Samoa	Tonga	Canada
Fidji	Japan	Georgia	Romania
Uruguay	USA	Namibia	Italy

Quarter Finals	Semi finals	Final
South Africa / **England**	England / **New Zealand**	**New Zealand** / France
New Zealand / Ireland	**France** / Australia	
France / Argentina		
Australia / Scotland		

Third Place

England	Australia

Commands in Stata

Declaring variables

- global national "south tropicar data785 data83 data1036 data454 data455 first catho80 "
- global team "feet perc mscrumweight msecond mcaps debut ranking"
- global exp "$team $national"

Estimating multinomial Probit (ideally with **mprobit2**)

- xi: mprobit2 score $exp, baseoutcome(6) robust correlation(ind)

Calculating marginal effects

- margins, dydx(*) exp(1-(predict(outcome(6))))
- margins, dydx(*) exp(1-predict(outcome(5))-predict(outcome(6)))
- margins, dydx(*) exp(predict(outcome(1))+predict(outcome(2)))
- margins, dydx(*) expression((1-predict(outcome(5))-predict(outcome(6)))/(1-(predict(outcome(6)))))

Conclusion

Key elements for success in RWU

- Have, a long tradition in rugby and many affiliated players
- Be in a good form period
- Come from the southern hemisphere
- Have a large share of coutry area outside the tropics
- Have a low infant mortality rate
- Have a large share of arable land
- Have a high second row and heavy scrum

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