12h International Schumpeter Society Conference

Innovation, ICT and Risk Aversion on the Growth of Firms in Less Developed Countries.

The Case of the Uruguayan Manufacturing Firms

Ricardo Pascale
University of the Republic, Uruguay

Jordi Vilaseca
Universitat Oberta de Catalunya, Spain

Rio de Janeiro, July, 2008

Agenda

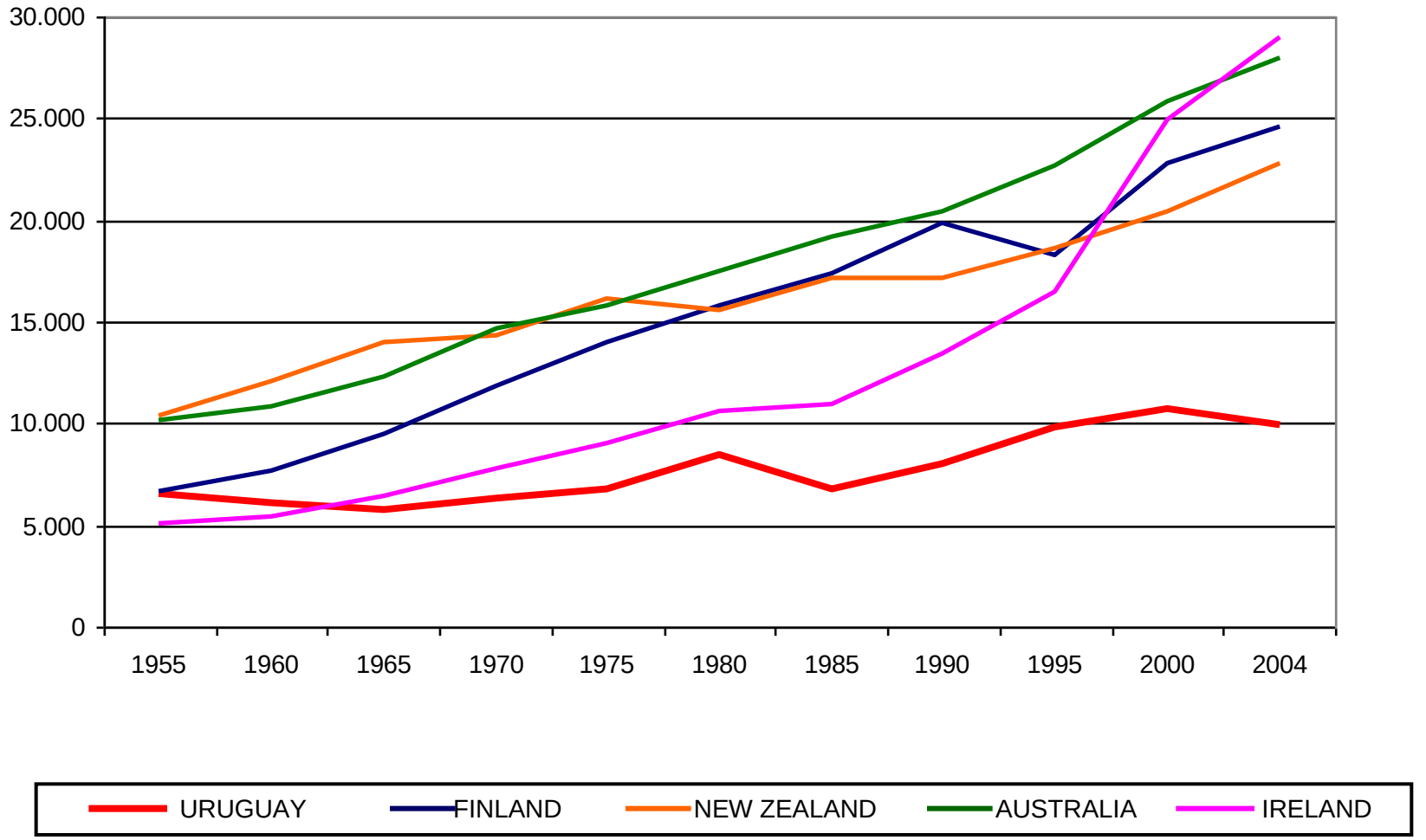
1. Motivation
2. Research Questions
3. Method
4. Data Set and Variables
5. Results
6. Conclusions
7. Policy Implications

1. Motivation

- ✓ Five decades of evidences of economic decadence
- ✓ What are the underlying causes of these large diferrences of economic growth between countries?
- ✓ The majority of the research on economic growth is done in developed countries and not in less developed countries (LDC) where the needs for research on growth are much higher.
- ✓ Most of the studies regarding economic growth in LDC are based in secondary variables with high level of aggregation and the research based in primary and microeconomic variables is practically non-existent.

1. Motivation

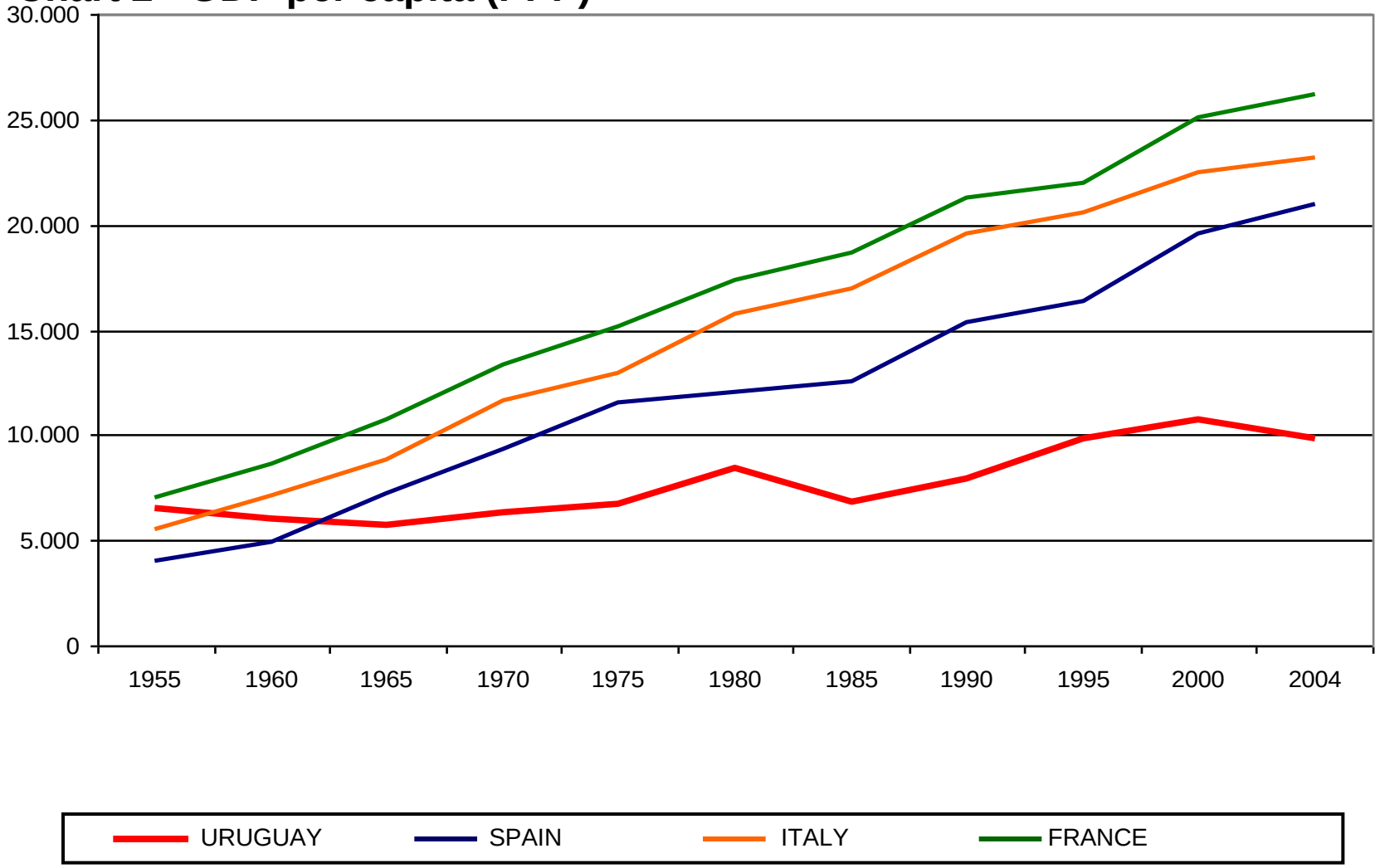
Chart 1 - GDP per Capita (PPP)



Source: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.2, Center for International Comparisons at the University of Pennsylvania (CICUP), September 2006.

1. Motivation

Chart 2 - GDP per capita (PPP)



Source: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.2, Center for International Comparisons at the University of Pennsylvania (CICUP), September 2006.

2. Research Questions

- Which are the determinants of the innovation dynamism of firms?

- What is the relationship between innovation and TFP growth?

- What variables explain the economic growth of firms?

3. Method I

✓ **Mainly Quantitative:**

- Survey : 252 firms
- Stratified sample (size, and T.I)
- Sample selection: +200 empolyees census;
- Other strata: optimal size and random selection.
- Global error of the sample: ±1.36% (99% confidence).

✓ **Qualitative techniques:**

- Discussion Groups (3).
- Semi-Structured Interviews (11)

3. Method II

- **Definition**
  - **Innovation**

    "Successful exploitation of new ideas"
  - Four dimensions: product, process, organization and commercialization innovation.
  - In each dimension of innovation, the analysis focused on the scope of innovation: for the firm, for the country, for Mercosur and for the world.
  - **TFP**
  - Residual using Standard Growth Accounting approach.

3. Method III

- **Models for the Determinants of Innovation**
  - Logistic regression (maximum likelihood estimation of the binary logit model).
  - The goodness-of-fit was studied through the likelihood-ratio test statistics.
  - The Wald statistic was obtained to analyze the variable significance. The Hosmer- Lemeshow Test was also used estimated probability values, and the Cox-Snell R-squared and the Nagelkerke R-squared in each logistic regression model were obtained.

3. Method IV

✓Model for the Links between Innovation and TFP

$$\Delta \ln TFP_i I = a\Delta(k-l)_i + bINNPROD_i + cINNPROC_I + dINNORG_i + \\ + eINNCOM_i + f\Delta yI + \sum g_{nj} TI_{ji} + \sum h_{sj} S_{ji} + \mu_i$$

$\Delta \ln TFP_i I$	=	Rate of variation of the TFP (in log) of the firm *i* of the *I* sector.
$\Delta(k-l)_i$	=	Rate of variation (in log) of quantity of capital per employee of firm *i*.
$INNPROD_i$	=	Product innovation as a dichotomous variable of firm
$INNPROC_I$	=	Process innovation as a dichotomous variable of firm *i*.
$INNORG_i$	=	Organization innovation as a dichotomous variable of firm i.
$INNCOMi$	=	Commercialization innovation as a dichotomous variable of firm *i*.
$\Delta y I$	=	Rate of variation of the output of the *I* sector of the firm
$TIji$	=	Technological intensity as a categorical nominal variable of the firm *i* of the *j* technology level
Sji	=	Size as a categorical ordinal variable of the firm *i* of the *j* size
μi	=	Random error term for firm *i*.

3. Method V

✓ **Model of the Growth of the Firm.**

- The model for growth of the firms was developed using the different data and results from the two previous modelizations, (the determinants of the innovation dynamism and the link between TFP and innovation).

4. Data Set and Variables

- The econometric estimation of the models was carried out using a new and original firm-level data set built up with the information collected during the survey.

- **On Data and Variables for the Determinants of Innovation**

- Dependant Variable: *Innovation* (Firms which have introduced at least one product or one process or organization or commercialization innovation in 2001-2004)

- Type of variable: Dichotomous

4. Data Set and Variables II

- ✓ **The Potential Explanatory Variables**

Table 1 - Potential Explanatory Variables used in Econometric Estimates of the Determinant of Innovation

Achronym	Proxy	Type
PROP	Majority proprietorship of domestic investors	Dichotomous
EXP	% of total sales assigned to exports	Continuous
RISK	Absolute Risk Aversion of entrepreneurs	Continuous
ENTREP.	Number of new projects started (2001-2004)	Continuous
PUBLPOL	Public Policies concerned with innovation	Dichotomous
KNOWL	Existence knowledge management with policies	Dichotomous
R&D	% of sales assigned to R&D	Continuous
ICT	Weighted Index of ICT used in: R&D, e-learning e-commerce, accounting, administrative affairs.	Continuous
SIZE	Size of firms (S1, 5-19; S2 20-99; S3, 100-199; S4, more than 200 employees)	Categorical Ordinal
TECHIN	Strata of technological intensity	Categorical Nominal
RPAT	Number of registered patents (2001-2004)	Continuous
R&D FIN	Financing of R&D with equity	Dichotomous
R&D FINE	Amount of R&D financed with equity	Continuous

Source: Pascale (2007)

4. Data Set and Variables III

✓ **The RISK Variable: A Closer View**

- The RISK variable, is a usually not included in the theoretical and empirical studies in highly developed countries regarding innovation as well as growth.
- The RISK variable was measured through the Absolute Risk Aversion (ARA), by Arrow (1965) and Pratt (1964). ARA was calculated for each entrepreneur, taking into consideration the cognitive insights of Tversky and Kahneman (1979, 1992), trying to reduce the possible existence of anomalies.

4. Data Set and Variables III

- ✓ **The RISK Variable: A Closer View**

ARA = $ap(w)_{ij}^{k} = \dfrac{-\mu''(w)_{ij}^{k}}{\mu'(w)_{ij}^{k}}$

Where :

- $\mu(w)_{ij}^{k}$ is the utility function of the *k* firm, of the size *I* and technological intensity *j.*

- The technique used was to fit the answer vector through least squared to the potential function.
  $\mu(w) = \alpha + \beta w^{\gamma}$

4. Data Set and Variables IV

- ✓ **On Data and Variables for the Analysis of the Link between Innovation and TFP**

- Obtained by means of the survey.
- The quantitative variables, were used in constant terms, using for these purposes the sectoral price indexes compiled by the Central Bank of Uruguay (BCU).
- The value added by the firms was calculated.

5. Results

✓ The determinants of Innovation

Logistic Regression results

Innovation	Product	Process	Organization	Commercializ.
Explanatory Variables	**ICT (+) RISK (-)**	**ICT (+) RISK (-)**	**KNOWL (+) RISK (-)**	**KNOWL (+) RISK (-)**
Overall Correct Prediction	83,33%	85,00%	78,37%	84,08%
Innovators Correct Prediction	73,40%	73,30%	17,54%	39,22%

5. Results II

The relationship between Innovation and TFP

Table 2 - Robust Estimation of the Explanatory Model of the Rate of Variation of the TFP (Δtfp): All the firms-Uruguay 2001-2004 (Method of Analysis: ordinary least squared; dependant variable: variation of the TFP, Captured as Δln TFP)

	Original Model	**RRE Included**
Explanatory Variables	*Coefficient*	*Coefficient*
$\Delta(k_{-1})$	-0,194*** (0,037)	-0,199*** (0,037)
INNPROC	0,342*** (0,044)	0,319*** (0.048)
Δy	0,290** (0,118)	0,227* (0.125)
RRE		0,231*** (0,056)
S2	-0,136*** (0,050)	
S3	-0,132** (0,057)	
Constant	-0,136*** (0,041)	-0,287*** (0,090)
	N= 148 F (5,147) = 25,078 Prob > F = 0,0000 Adjusted R^2 = 0,469	N= 148 F (4,143) = 31,564 Prob > F = 0,0000 Adjusted R^2 = 0,568

Significant levels *** 1%, ** 5% ,* 10%
Robust standard errors are shown in parentheses

5. Results III

- ✓ **A Model of the Growth of Firms in Uruguay**

- Which factors explain the growth of the firms in Uruguay?

- Is TFP different to zero? Which is the role of ICT and RISK in this explanation?
- The INNPROC explains the rate of change in TFP. It was found that the INNPROC was determined by ICT and RISK.

- **TFP** ⟶ **INNPROC** ⟶ **ICT** and **RISK.**

- To analyze this relationship the formalized model was:

$$\Delta tfp_i = a\Delta(k-l)_i + bICT_i + cRISK_i + dRRE_i + \sum njTI_{ji} + \sum_{sj} S_{ji} + \mu_i$$

- Where the variables are already defined.

5. Results IV

A Model of Growth of Firms in Uruguay

Table 3 - Robust Estimation of the Explanatory Model of the Rate of Variation of the TFP (Δtfp): All the firms-Uruguay 2001-2004 (Method of Analysis: ordinary least squared; dependant variable: variation of the TFP, Captured as Δln TFP)

	All the Firms	**High Technology Firms**
Explanatory Variables	*Coefficient*	*Coefficient*
Δ (k $_{t-1}$)	-0,278***	-0,167***
	(0,035)	(0,061)
RRE	0,161***	
	(0,056)	
RISK	-0,334***	-0,457***
	(0,054)	(0,126)
ICT		0,285**
		(0,134)
Constant	0,008	-0,009
	(0,051)	(0,132)
	N= 148 F (3,144) = 48,008 Prob > F = 0,0000 Adjusted R^2 = 0,675	N= 34 F (3,30) = 10,081 Prob > F = 0,0000 Adjusted R^2 = 0,714

Significant levels: *** 1% , ** 5% ,* 10%
Robust Standard errors are shown in parentheses

5. Results IV

✓ **A Model of the Growth of Firms in Uruguay**

- For the long term consideration –with the available information –the model obtained is:

$$Y = A\,(ICT, RISK)\; K^{\alpha}\; L^{(1-\alpha)}$$

- The product (**Y**) not only depends on labor (**L**) or human and physical capital (**K**), but also on other variables. It also positively depends on the use of **ICT**, and negatively on **RISK**, a proxy of the risk aversion of the entrepreneurs. **RISK** has a significant weight on the results and, therefore, on the results of growth. This negative effect cannot be –for the time being- compensated by the use of **ICT**.

6. Conclusions

- ✓ **In relation to which are the determinants of innovation of firms, they are:**

a) Uruguay shows a weak innovative dynamism, based on *imitation* and *technology adoption* through new equipment acquisition.

b) Two variables explain the innovation dynamism, and those are **RISK** and **ICT**.

c) **ICT**, that improves knowledge and innovation, positively affects the dynamism in process and product innovation. In organization and commercialization innovation, **KNOW**, a variable with closer associations with **ICT** explains the positive forces to innovate.

d) **RISK** has a negative influence on the innovation dynamism of uruguayan firms. It is practically non-existent in models for developed countries (follows a "normal" path). **RISK** was the unique explanatory variable that remains in the four dimensions of the innovation.

6. Conclusions II

- ✓ **In relation to the links between innovation and TFP, they are:**

a) **INNPROC** has a positive effect on the explanation of ∆**lnTFP**. The other dimensions of the innovation with the data available did not appear as explanatory variable.

b) Due to the positive association between **INNPROC** and **ICT**, this last one seems to have a positive influence on the growth of **TFP**.

c) The sectoral growth also positively affects ∆**lnTFP** and, in the analyzed period, the capital per worker affects negatively ∆**lnTFP**.

6. Conclusions III

- ✓ **In relation to the explanatory variables of economic growth of firms, they are:**

a) With the available information, a long term model was obtained for this question: This model is:

$$Y = A\,(ICT, RISK)\,K^{\alpha}\,L^{(1-\alpha)}$$

b) The variation of the product of the firm (**Y**) not only depends on **L** or **K** (human and physical capital), it also depends positively on the use of **ICT**, and negatively, on **RISK**. The negative effect of **RISK** has a severe weight in the results of the function and seems to be not compensated by **ICT.**

c) A non-explaining, specific residual still remains, and seems to rest in institutional considerations.

7. Policy Implications

- ✓ The policy implications of these findings are crucial for economic growth.
- ✓ The challenge to diminish RISK.
- ✓ To reduce the remaining non-explained specific residuals.
- ✓ Public policies on innovation, which in the preliminary findings seem to have a positive effect; nevertheless, the final answer to this issue still remains open.