



Reintegration of disabled workers to labor market. A stochastic analysis based on the Continuous Sample of Working Lives

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About the speaker



- **Víctor Vilà Prats**– *Actuarial Consultant, Deloitte Advisory S.L. Business Administration Degree in Pompeu Fabra University, Barcelona. Actuarial Science Master in Universidad de Málaga, Málaga. Expertise in calculation engines implementations for solutions End-to-End for IFRS 17 in Deloitte Advisory S.L.*



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Introduction

- Context of the work
 - Total Permanent Disability (TPD) and its compatibility with a job
- Previous Works and studies
 - Complexity of the study
 - Methodologies used



Total Permanent Disability (TPD)

- Concept
- Compatibility between pension and employment
- Requirements and amounts
 - <55 years -> Regulatory Base*55% (TPD)
 - \geq 55 years -> Regulatory Base*75% (Qualified TPD)



Scope of the Study

Main Objectives

- “To know the characteristics and behaviour of the subjects with a TPD in relation to their ability to reconcile the benefit with employment”
 - Determine the variables sensitive to study and their influence on the possibility of compatibility.
 - *Methodology: Descriptive Analysis*
 - Prepare a table of compatibility probabilities according to the age of the individual.
 - *Methodology: Stochastic Analysis – Probability Table*
 - Study the time it takes for an IPT to enter the labor market.
 - *Methodology: Stochastic Analysis – Cox’s Model*



Scope of the Study

Database and Variables

- Database
 - Continuous Sample of Working Lives (CSWL), 2016
 - Retrospective Information
 - Profile/characteristics of the subjects
 - Benefits of pensions
 - Contributions
 - Target Profile
 - Pensioner in TPD at some point in time
 - Under 65 years at 31 december 2016



Scope of the Study

Database and Variables

- Software
 - MySQL
 - Rstudio
 - Office

- Variables used
 - Biometric (age at disability, gender)
 - Economic (activity, contribution group, regulatory base, average amount of the benefit)
 - Other variables related (nationality, regular residence, degree of disability)

Scope of the Study

Metodology I



- Descriptive Analysis
 - Metrics (univariate and multivariate analysis)
 - Graphics
- Probability Table
 - Gross Probability
 - $q_x^{TPD,CONT} = d_x/l_x$, where:
 - $d_x =$ Subjects TPD at Age x that in Age $x + 1$ have contributed
 - $l_x =$ Subjects TPD at Age x
 - Probability Smoothing
 - Cubic Spline Interpolation – Leave-One-Out Cross Validation
 - Time Remaining Expectancy (outside labor market)
 - $e_x = \sum_{k=1}^{64-x} k p_x$

Scope of the Study

Metodology II – Cox Model

- Formulation

- Hazard Function (**Baseline & Proportional Hazards**)

- $\lambda(t, \mathbf{X} = (x_1, \dots, x_p)) = \lambda_0(t) \cdot e^{\beta_1 \cdot x_1 + \dots + \beta_p \cdot x_p} = \lambda_0(t) \cdot e^{\sum_{j=1}^p \beta_j \cdot x_j}$

- Validation Tests

- Proportional Hazards

- $(\lambda_0(t) \cdot e^{\sum_{j=1}^p \beta_j \cdot \mathbf{X}_j^*}) : (\lambda_0(t) \cdot e^{\sum_{j=1}^p \beta_j \cdot \mathbf{X}_j}) = e^{\sum_{j=1}^p \beta_j \cdot (\mathbf{X}_j^* - \mathbf{X}_j)}$

- Parameters and global estimation tests.

- Specialized Variants

- Stratified Cox Model

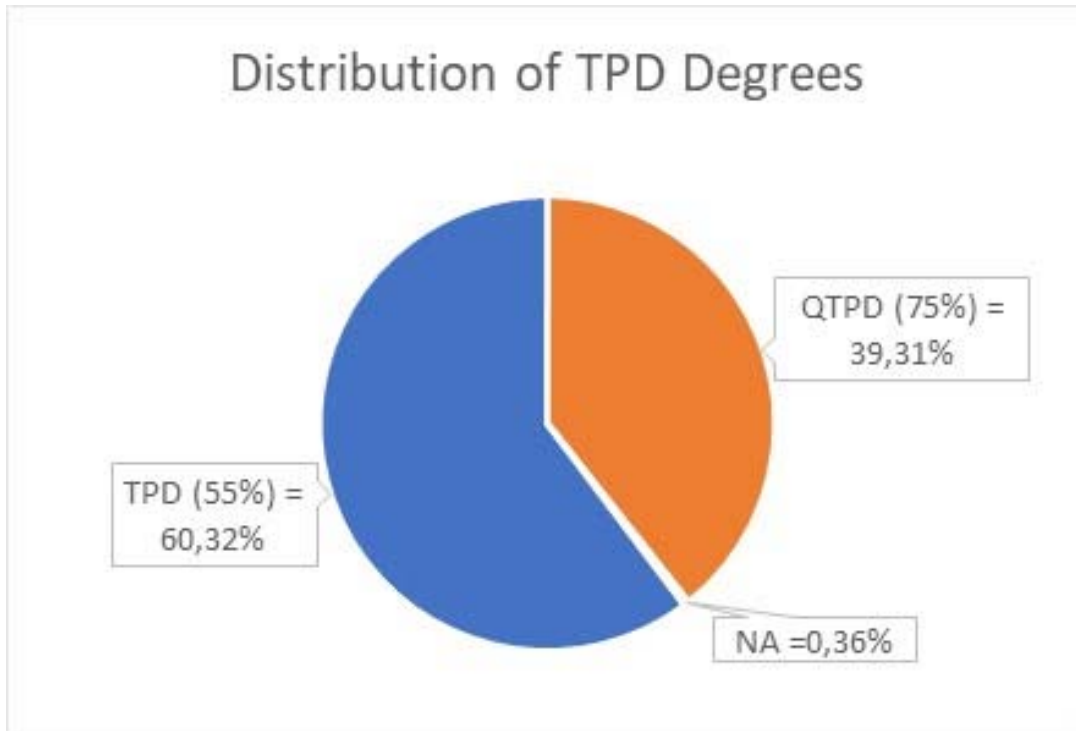
- $\lambda_g(t, \mathbf{X}) = \lambda_{0g}(t) \cdot e^{\sum_{j=1}^p \beta_j x_j}, \quad Z^* \ni g = [1, \dots, k^*]$

- Stratified Cox Model with Interaction Test

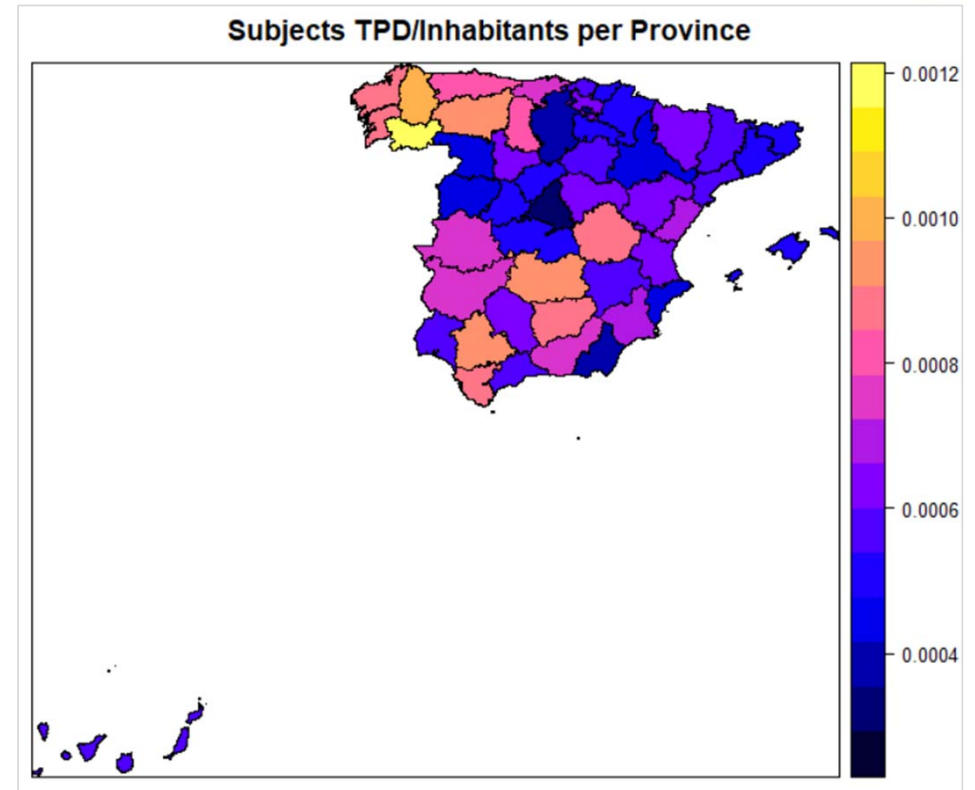
- $H_0: \beta_{11} = \dots = \beta_{p1} = \beta_{12} = \dots = \beta_{p2} = \beta_{1(k^*-1)} = \dots = \beta_{p(k^*-1)} = 0, \quad LR \sim \chi_{p(k^*-1)}^2$

Results

Descriptive Analysis – Univariate I



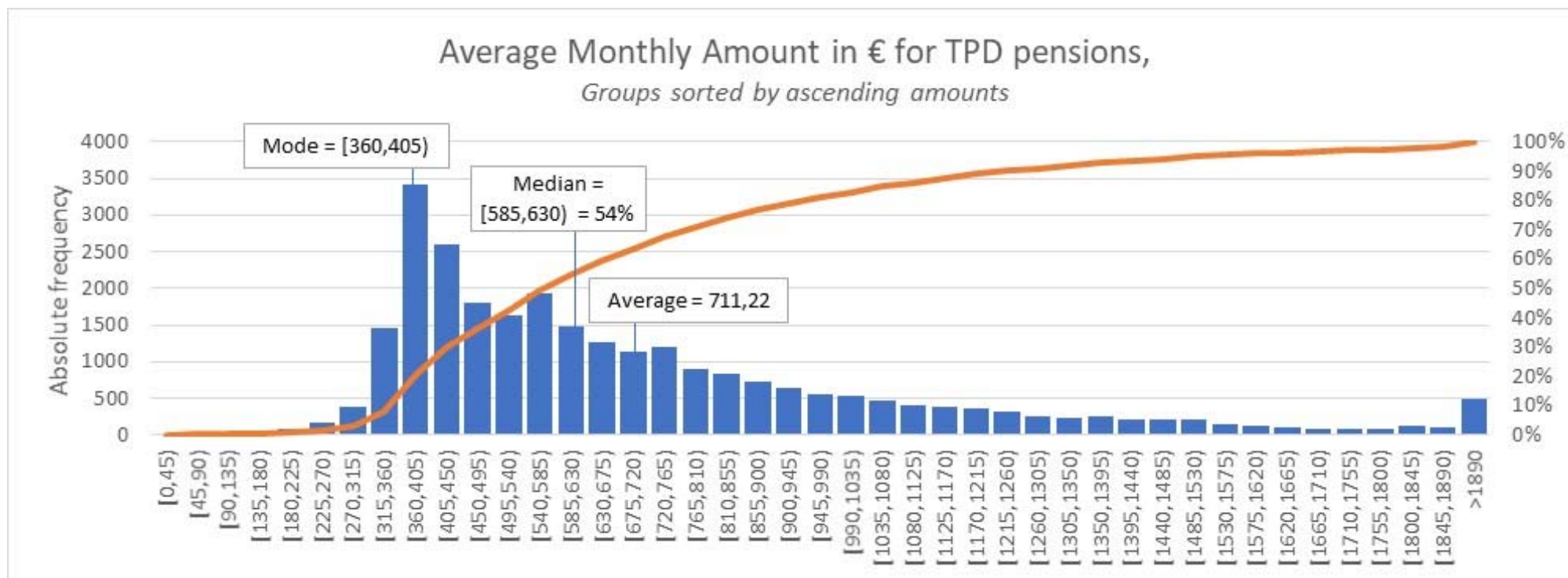
Graphic 1. Distribution TPD by Degree. Source: Own work



Graphic 2. Distribution TPD by Province. Source: Own work

Results

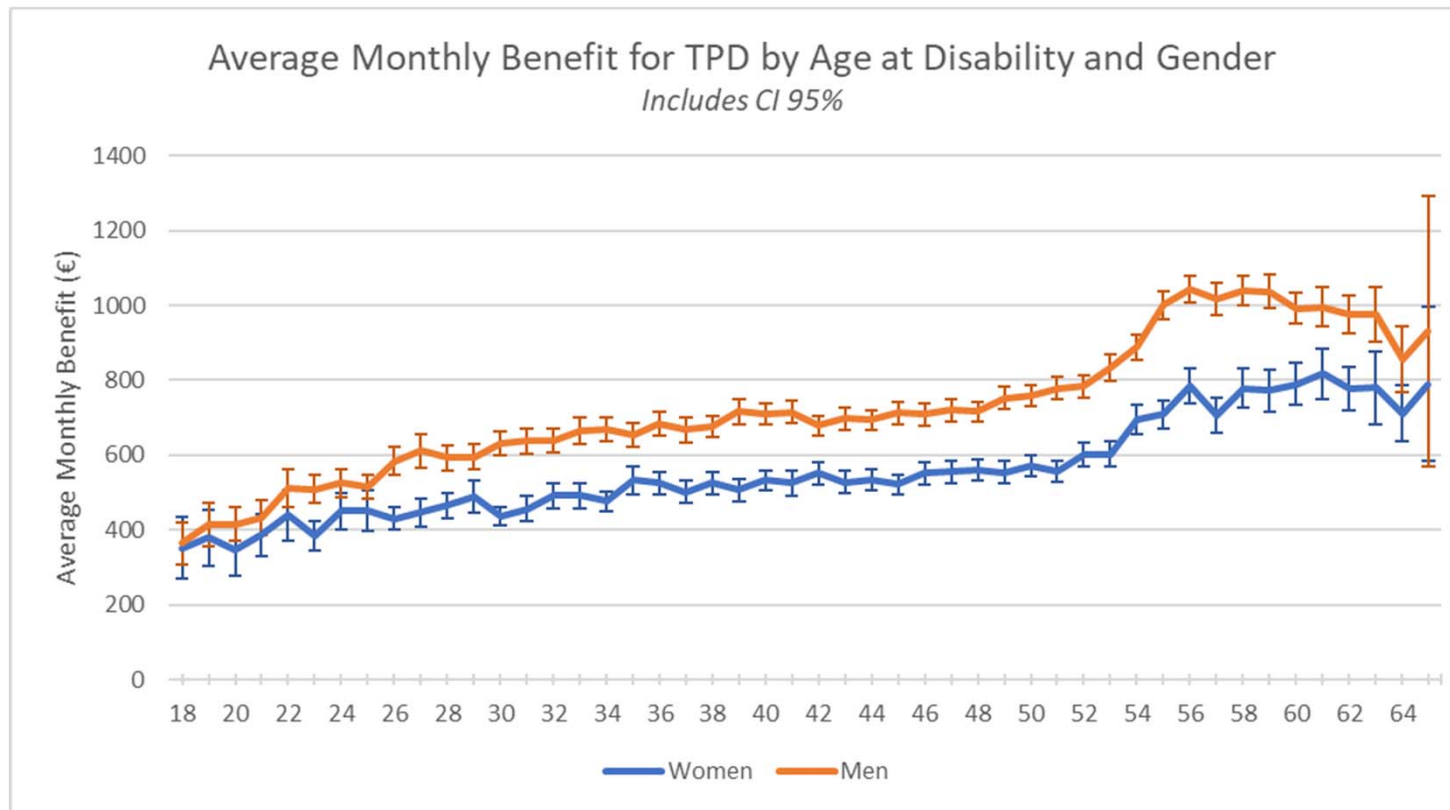
Descriptive Analysis – Univariate I



Graphic 3. Distribution of average monthly amount in € for TPD pensions. Source: Own work

Results

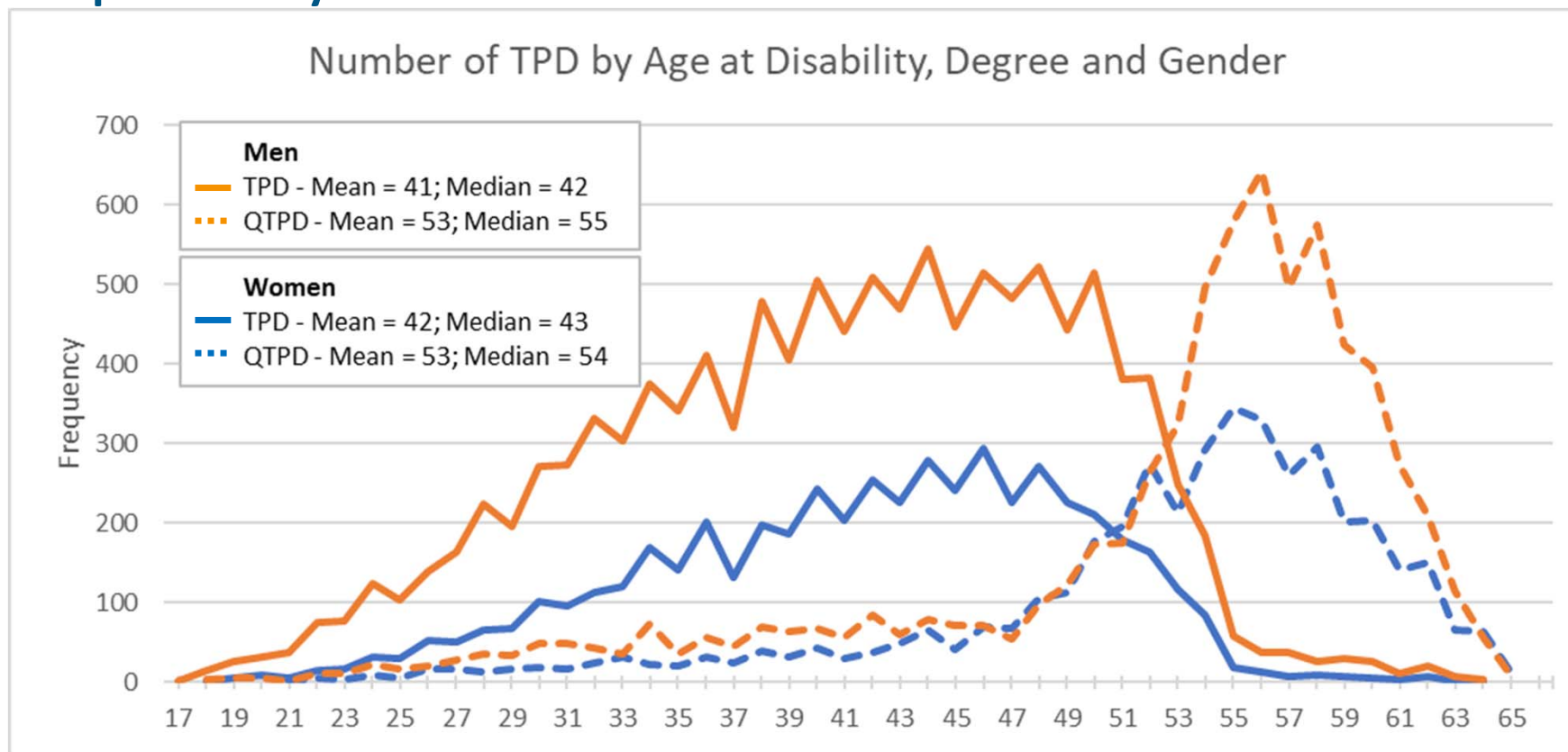
Descriptive Analysis – Multivariate III



Graphic 4. Average Monthly Benefit for TPD by age at disability and gender. Source: Own work

Results

Descriptive Analysis – Multivariate III



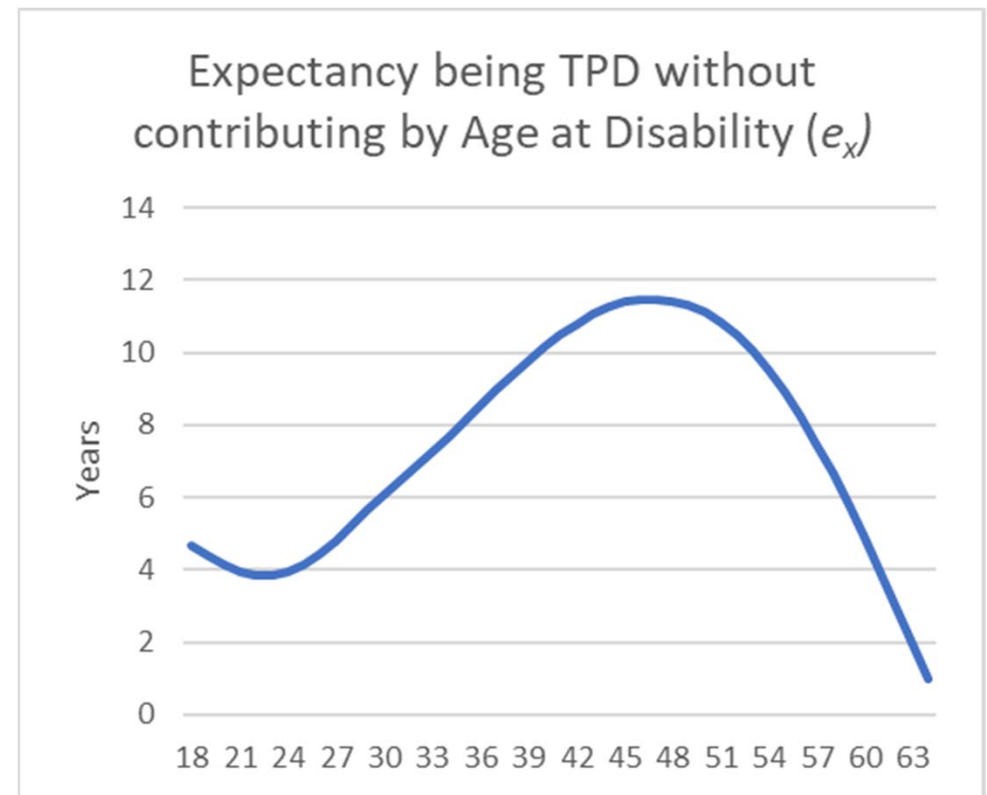
Graphic 5. Distribution of number of TPD by age at disability, degree and gender. Source: Own work

Results

Stochastic Analysis – Probability Table

Age (x)	$q_x^{TPD, CONT SMTH}$	Age (x)	$q_x^{TPD, CONT SMTH}$	Age (x)	$q_x^{TPD, CONT SMTH}$
18	0,130362993	34	0,157429776	50	0,061796692
19	0,148046282	35	0,150969994	51	0,056297942
20	0,166636325	36	0,143293977	52	0,051066889
21	0,184822038	37	0,135241642	53	0,046049593
22	0,202834224	38	0,128159705	54	0,040265078
23	0,219741283	39	0,122079414	55	0,033530011
24	0,233126525	40	0,116331641	56	0,027094244
25	0,239807401	41	0,111187198	57	0,021617355
26	0,238435643	42	0,105403868	58	0,017381765
27	0,229201346	43	0,098616535	59	0,014212565
28	0,213425340	44	0,091805275	60	0,011823921
29	0,197332297	45	0,085903962	61	0,010080212
30	0,184908896	46	0,080938821	62	0,009116433
31	0,176823668	47	0,076436917	63	0,008784828
32	0,170250614	48	0,071707289	64	0,008852408
33	0,163833967	49	0,066931961		

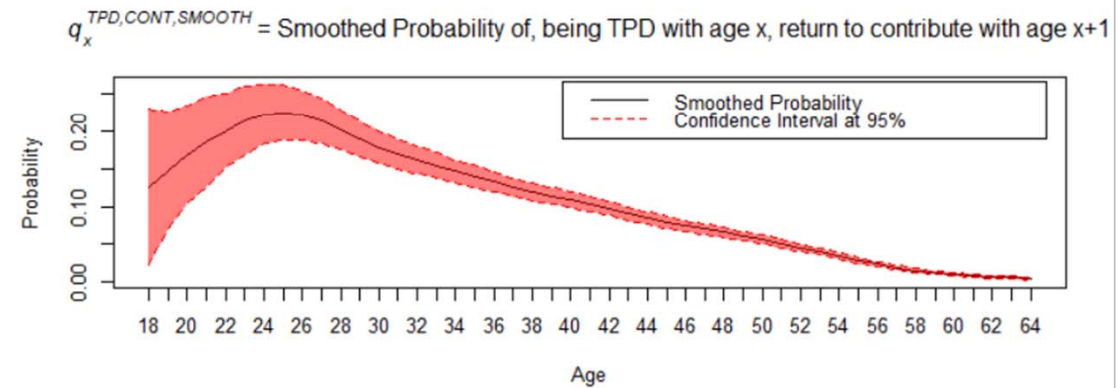
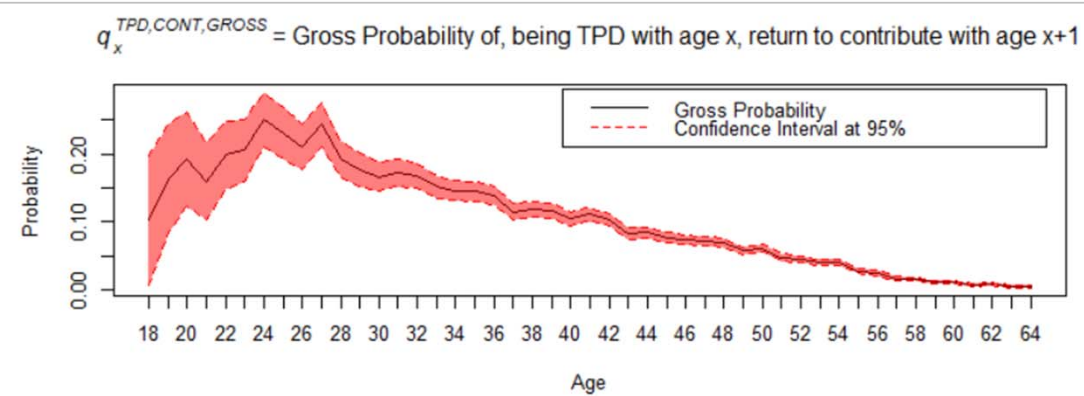
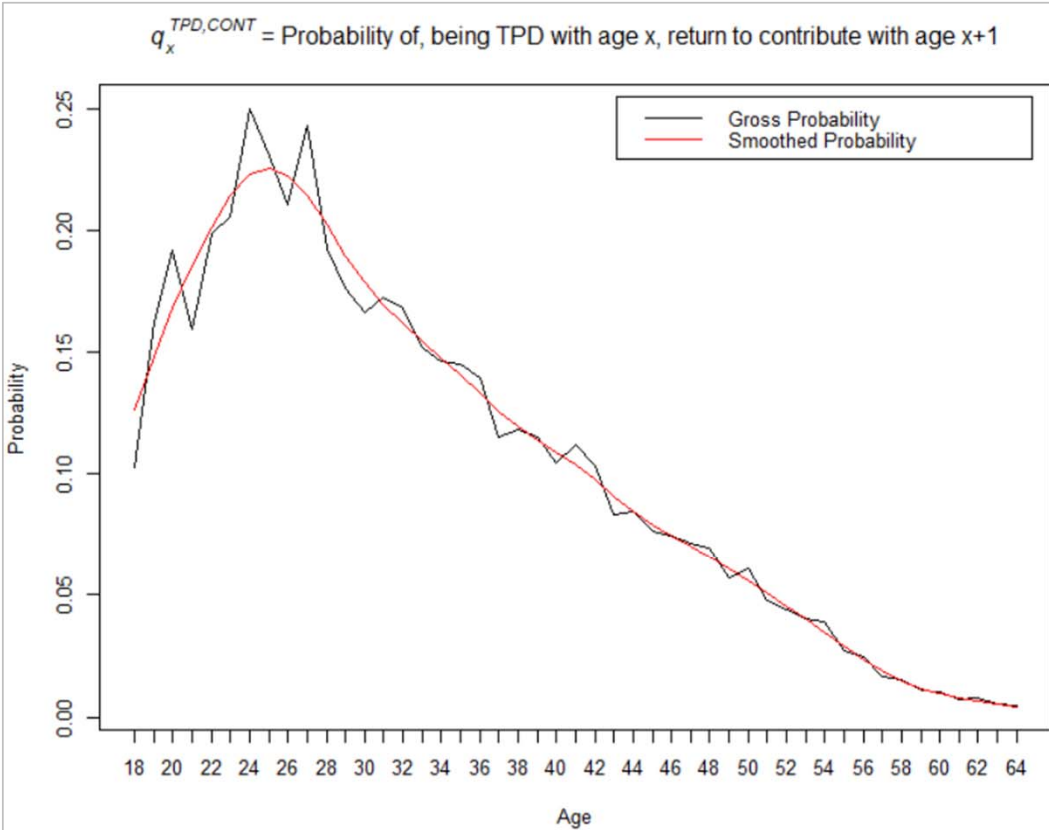
Table 1. Probability Table, Smoothed . Source: Own work



Graphic 6. Years expected being TPD w/o contributing. Source: Own work

Results

Stochastic Analysis – Probability Table



Graphics 7-9. Gross and Smoothed probabilities of being TPD at age x, return to contribute with age x+1. Source: Own work

Results

Stochastic Analysis – Cox Model Estimation

- “Survival Function”

- Without Interaction/Individual

- . $\lambda_g(t, \text{gender}, \text{years}) = \lambda_{0g}(t) \cdot e^{\beta_{\text{gender},g} \cdot \text{gender} + \beta_{\text{years},g} \cdot \text{years}}$

- With Interaction

- . $\lambda_g(t, \text{gender}, \text{years}, \text{TPD}) = \lambda_{0,g}(t) \cdot e^{\beta_{\text{gender},g} \cdot \text{gender} + \beta_{\text{years},g} \cdot \text{years} + \beta_{\text{gender},g} \cdot \text{gender} \cdot \text{TPD} + \beta_{\text{years},g} \cdot \text{years} \cdot \text{TPD}}$

- Baseline Categories

- . Gender: Male

- . TPD: Qualified TPD

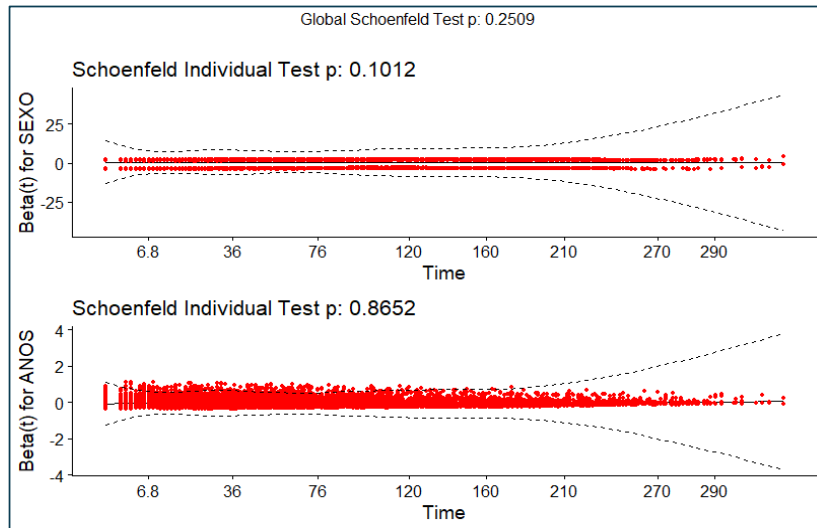
Model	β_{gender}	β_{years}
Without Interaction	0,561932	-0,0942954
Individual – TPD	0,598018	-0,055687
Individual – QTPD	0,439339	-0,075708
With Interaction – TPD	0,439339 + 0,158679 = 0,598018	-0,075708 + 0,020020 = -0,055687
With Interaction – QTPD	0,439339	-0,075708

Table 2. Parameter values by model variations. Source: Own work

Results

Stochastic Analysis – Cox Model Tests

Model Validation Tests



Graphic 10. Global and Individual Schoenfeld Residual Test. Source: Own work

Assumption Tests – p_value	w/o Inter.	Individual (TPD, QTPD)	w/ Inter.
Wald (Param. - gender)	<2e-16	<2e-16 , <2e-16	<2e-16
Wald (Param. - years)	<2e-16	<2e-16 , <2e-16	<2e-16
Wald (Param. – gender·TPD)			4.5e-3
Wald (Param – years ·TPD)			5.2e-4
Wald (Global)	<2e-16	<2e-16 , <2e-16	<2e-16
Likelihood Test (Global)	<2e-16	<2e-16 , <2e-16	<2e-16
Score Test – LogRank (Global)	<2e-16	<2e-16 , <2e-16	<2e-16

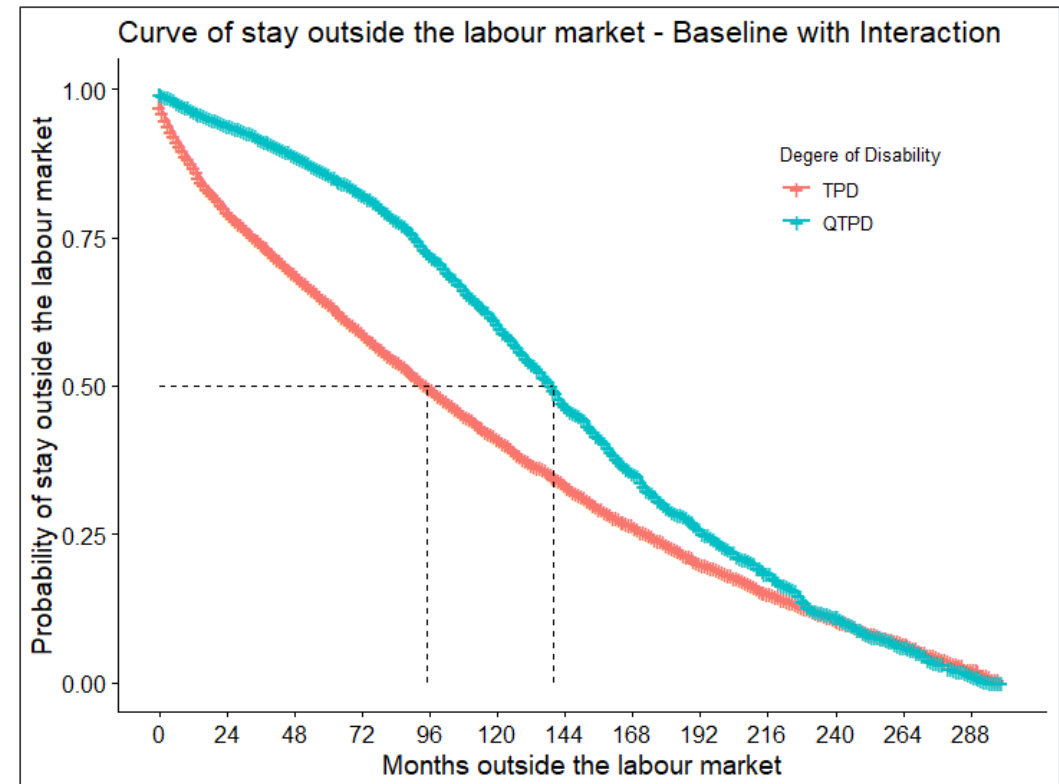
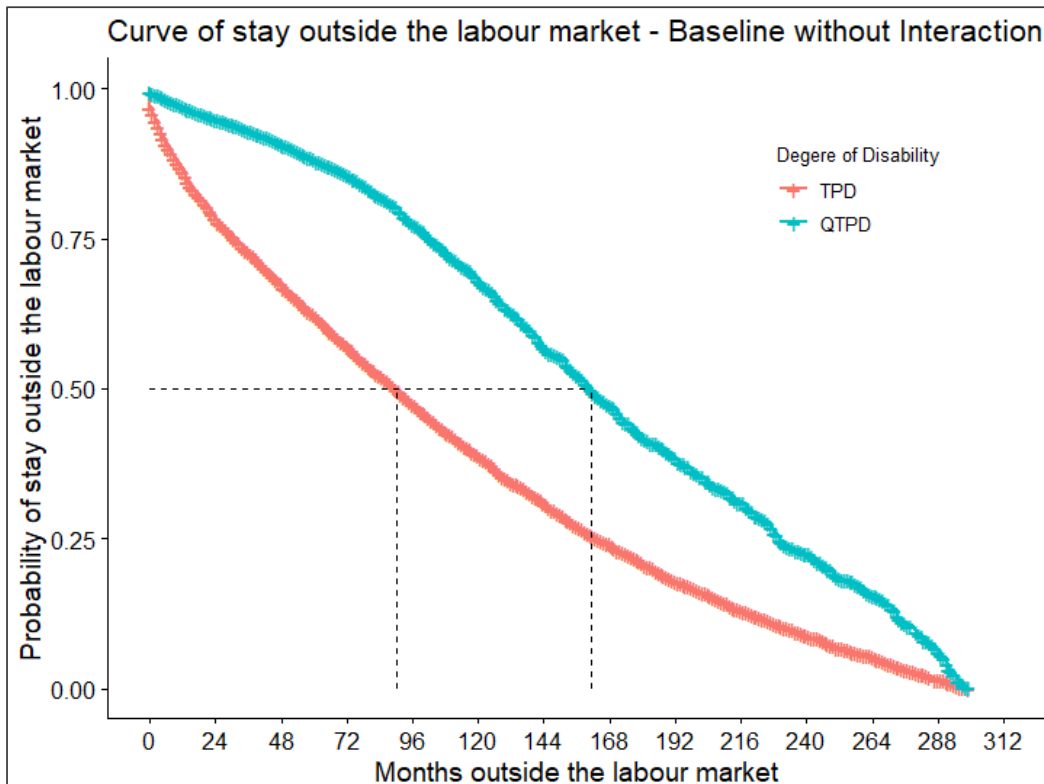
Table 3. Parameter and Global Estimation Tests. Source: Own work

No Interaction Test

– . $LR \sim \chi^2_{p(k^*-1)} \rightarrow p_{value} = 2e^{-16} \rightarrow \text{Reject } H_0 \rightarrow \text{Accept Stratified Cox Model with Interaction}$

Results

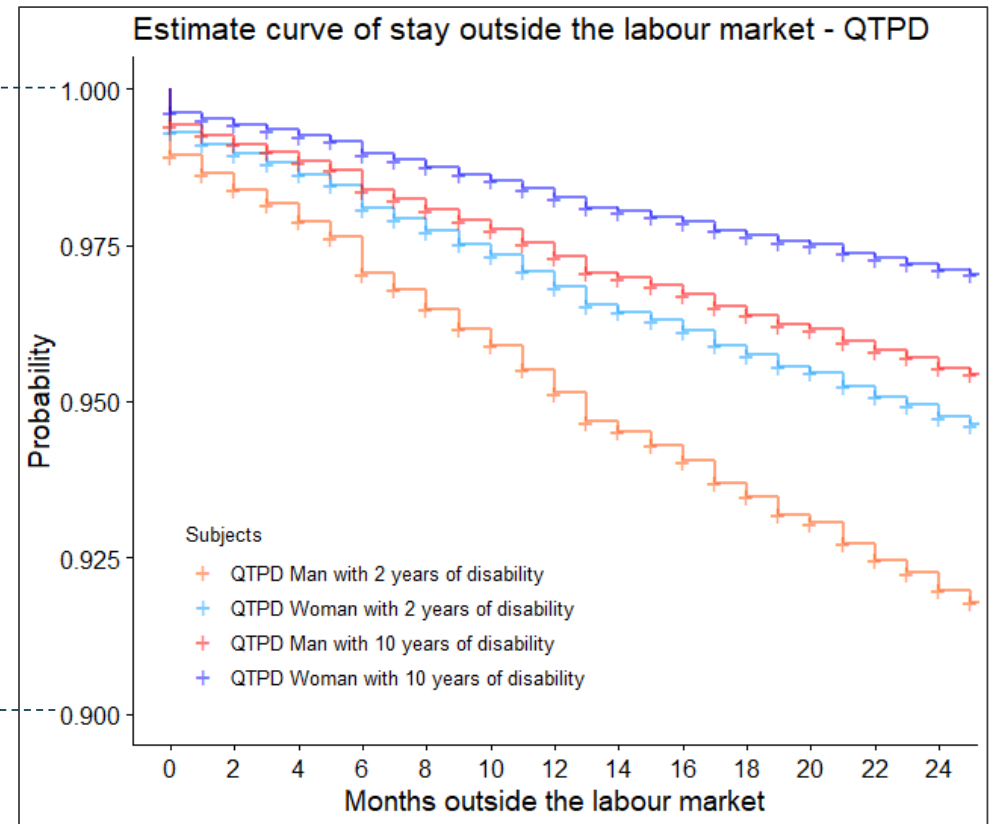
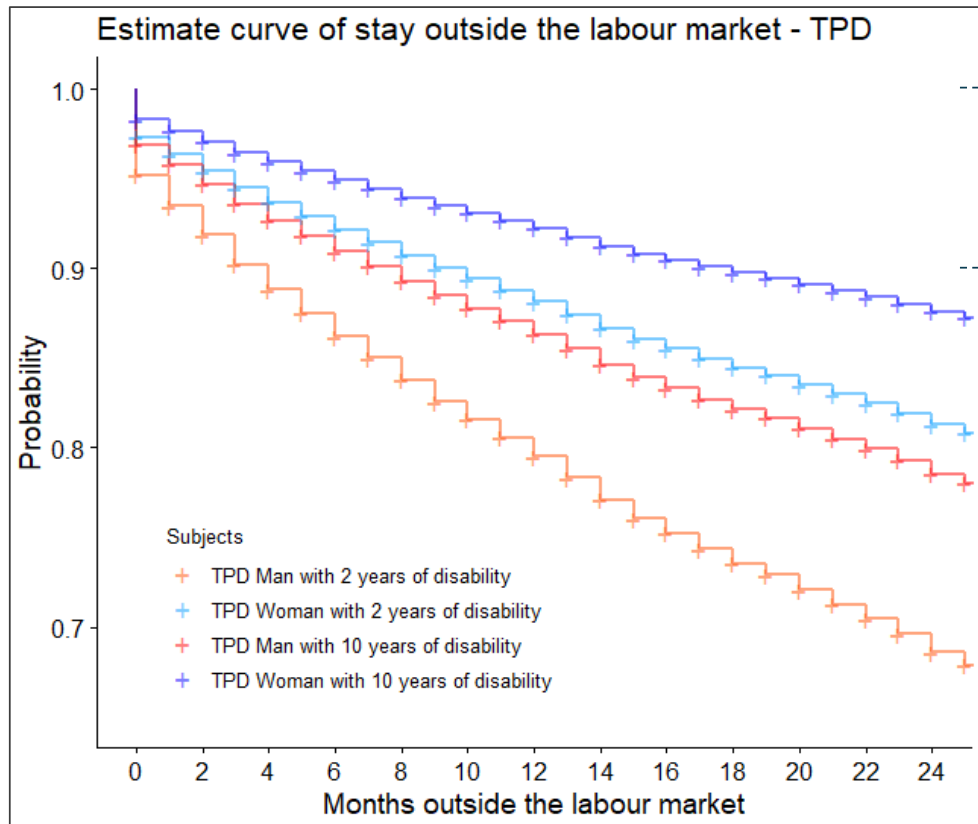
Stochastic Analysis – Baseline Cox Model



Graphics 11-12. Baseline curves of stay outside the labour market, with and without interaction Cox model results. Source: Own work

Results

Stochastic Analysis – Stratified Cox Model with Interaction



Graphics 13-14. Estimate curves of stay outside the labour market, Stratified Cox Model with Interaction, different subjects. Source: Own work

Conclusions

■ Descriptive Analysis

- Men, spanish, 46 years, peninsular northwest
- Construction sector, first and second class officers
- Average amount: 711€, 60% Base TPD (55% Regulatory Base)

■ Stochastic Analysis – Probability Table

- Higher probability of reincorporation at 25 years
- Lower time expectancy as TPD without contributing between 18-23 years (4 years)
- Higher time expectancy as TPD without contributing at 47 years (11 years and a half)

■ Stochastic Analysis– Stratified Cox Model

- Lower Probabilities to return at labor market for women, with more years being TPD and with Qualified TPD

- Obtaining resources for:
 - Design of active employment policies
 - Reflection about TPD pension
 - Review of the definition of coverage



Thank you

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