MODEL FOR CALCULATING OPERATIONAL CAPACITIES IN SERVICE PROVIDERS USING SYSTEM DYNAMICS

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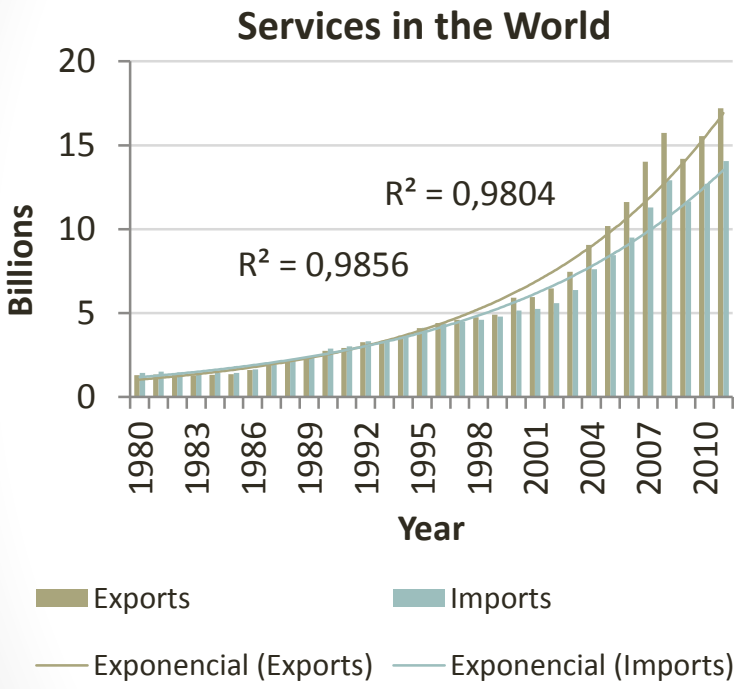
Outline

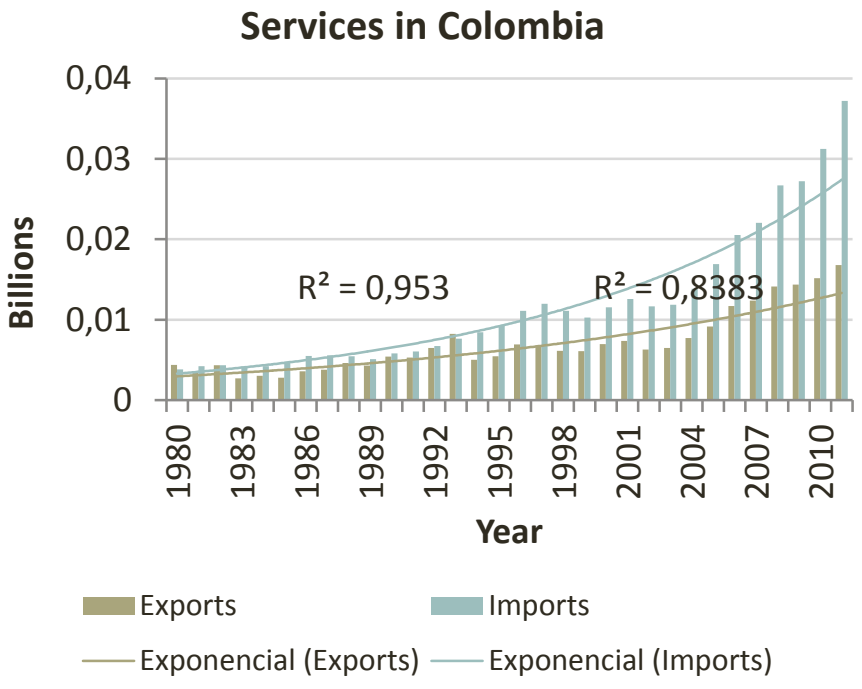
- Motivation
- Hypothesis
- Methodology
- Model
- Conclusions
- Future works

Motivation

Motivation

Service industry





Source: World Trade Organization

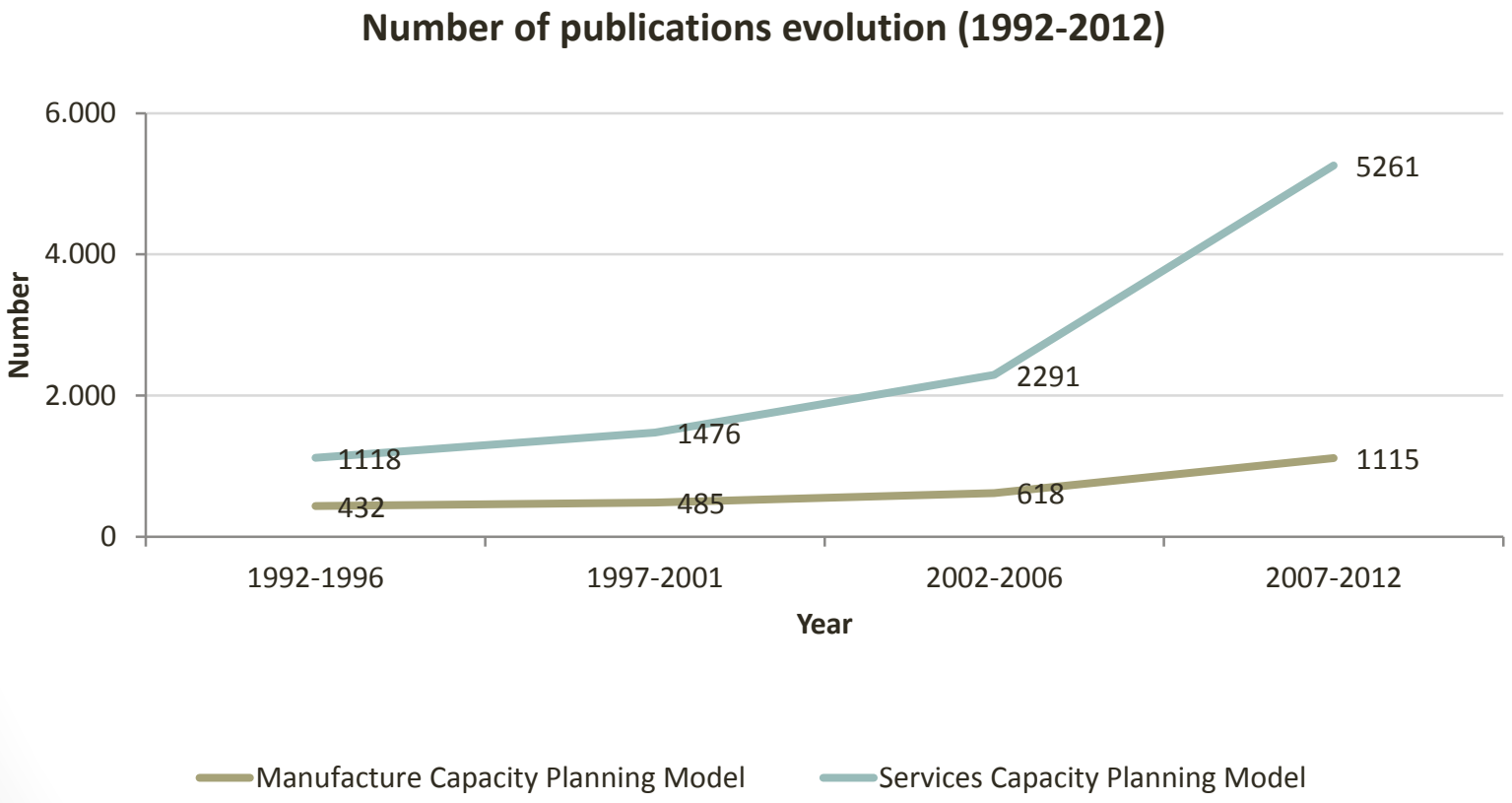
Motivation

Service industry

- The financial sector in Colombian:
  - shows the highest growth in the GDP between the first quarter of 2012
  - comparing with the same quarter last year **(6.7%)** after mining sector **(12.4%)**
- In 2012 the Annual Survey of Services 2010:
  - which includes 5,343 companies, shows the total staff employed 346,371 people
  - ***service companies*** corresponds to **21.6%**, compared with **31.3%** manufacturing industry
- The Financial Superintendence of Colombia in the same year:
  - highest profit percentage (23.6%) recorded the credit institutions

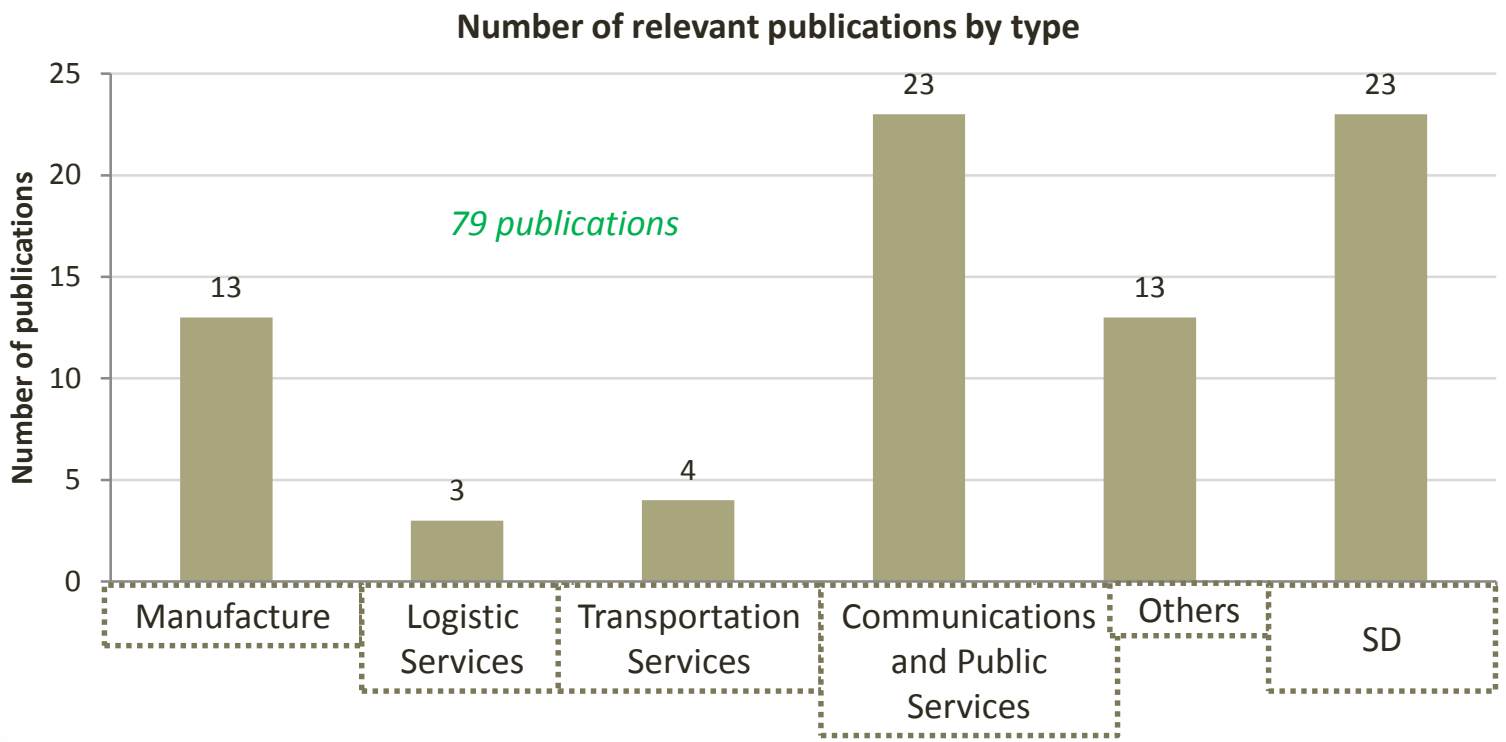
Motivation

Publications



Motivation

Publications



Motivation

Publications

From the review it can be said that within the **capacity planning models** and even services that apply system dynamics,

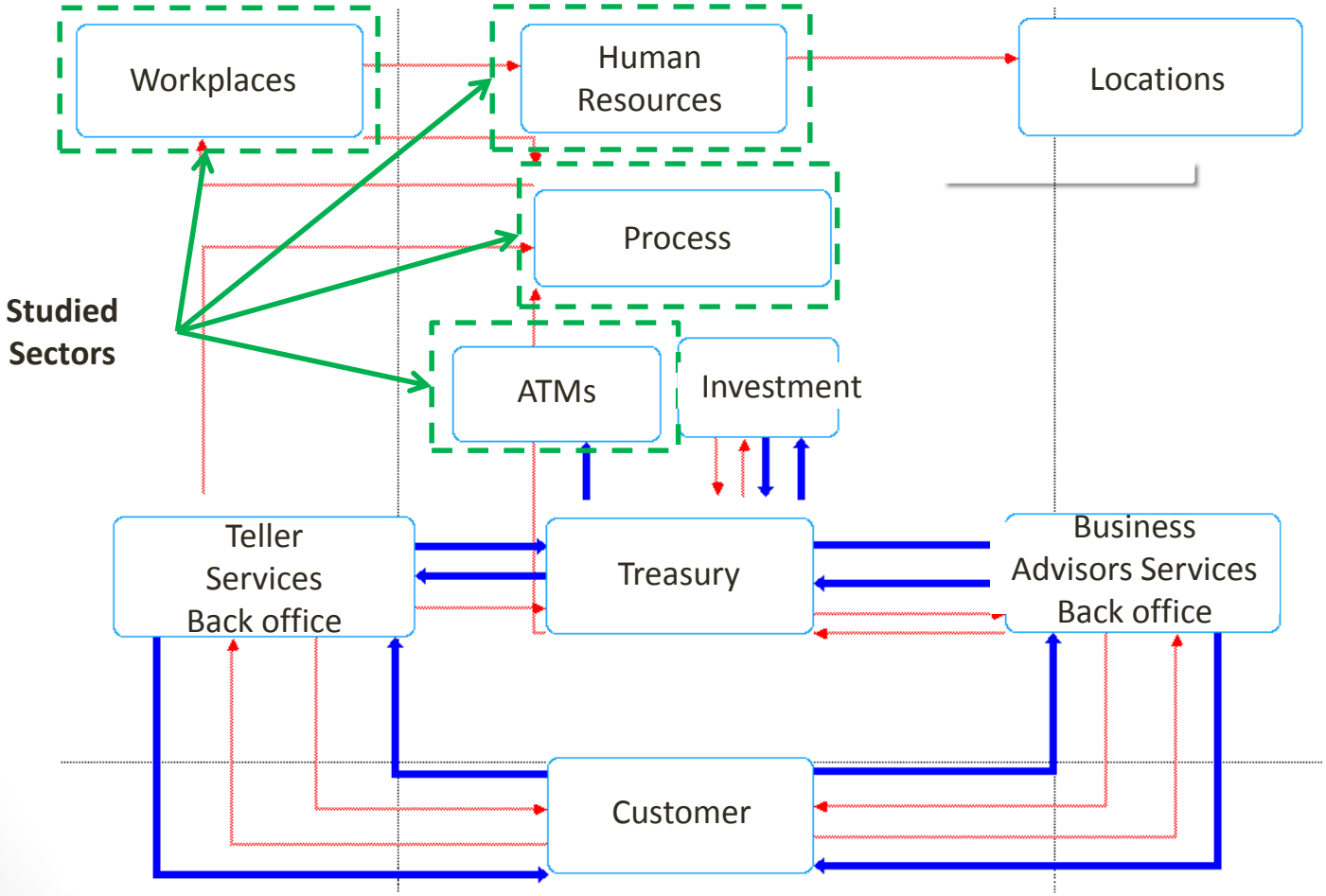
are **not considered fully the elements** included in the model result of this research,

specifically behavior analysis of **allocated workforce** and related **workstations** by operative processes and **work shift** in the fields of human resources, workstations and **electronic payments**.

Motivation

References

Comprehensive and dynamic model



Motivation

Problem

Establishing the importance of the **workforce allocation** study in the service industry,

specifically in credit institutions of the Colombian **financial sector**,

given its complexity and the dynamic relationship between the **operational capacity determination** in offices (workers and workstations),

with respect to **fluctuations in transactional demand** of system, which addressed the problem through system dynamics.

Hypothesis

Hypothesis

With the development of **capacity model using system dynamics** in this research,

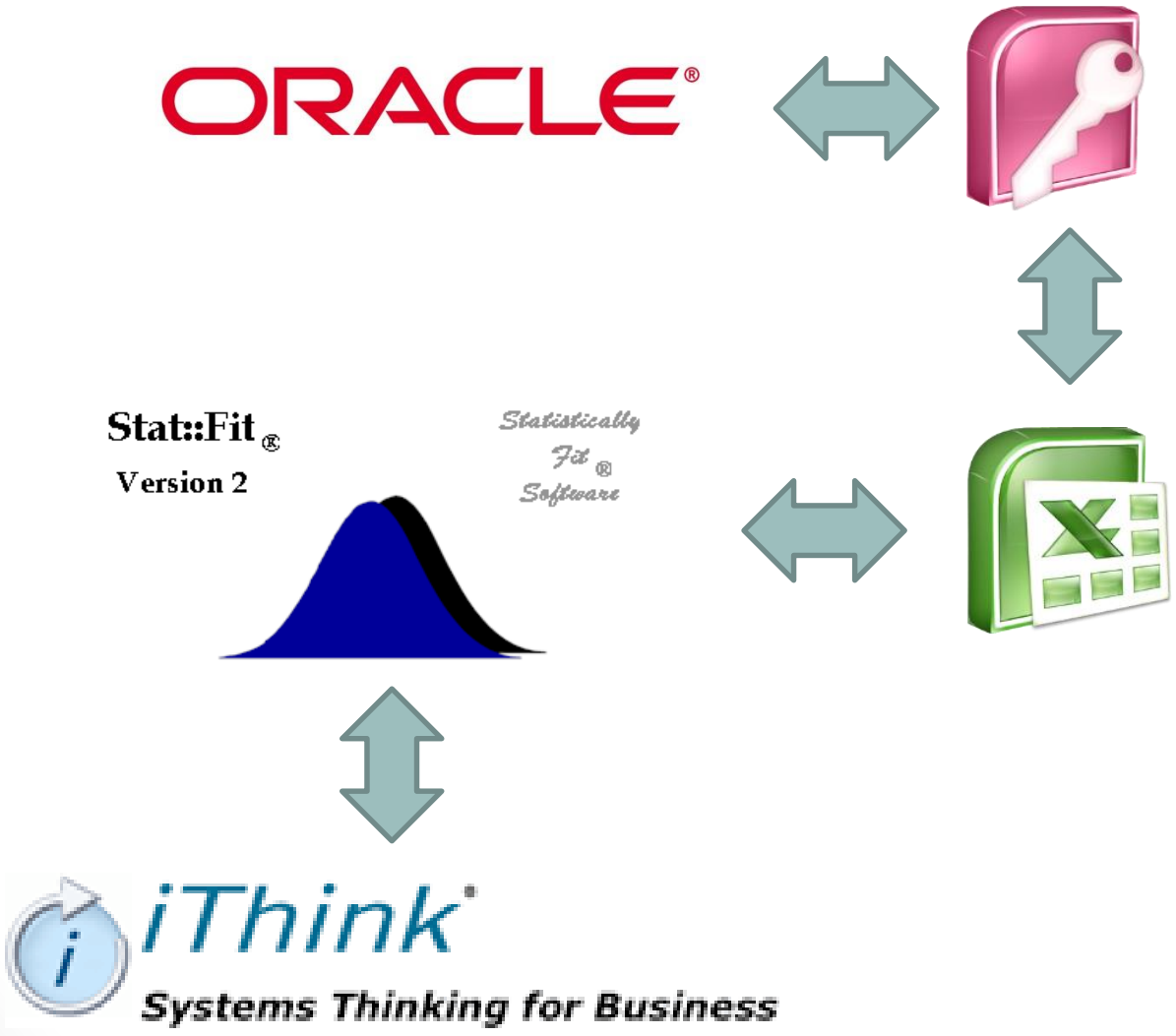
we seek to test the **hypothesis which considers dynamic with variable demand**, allocating appropriate levels of workers and workstations in the services;

it achieves a **maximum use of the resources capacity** in the system.

Methodology

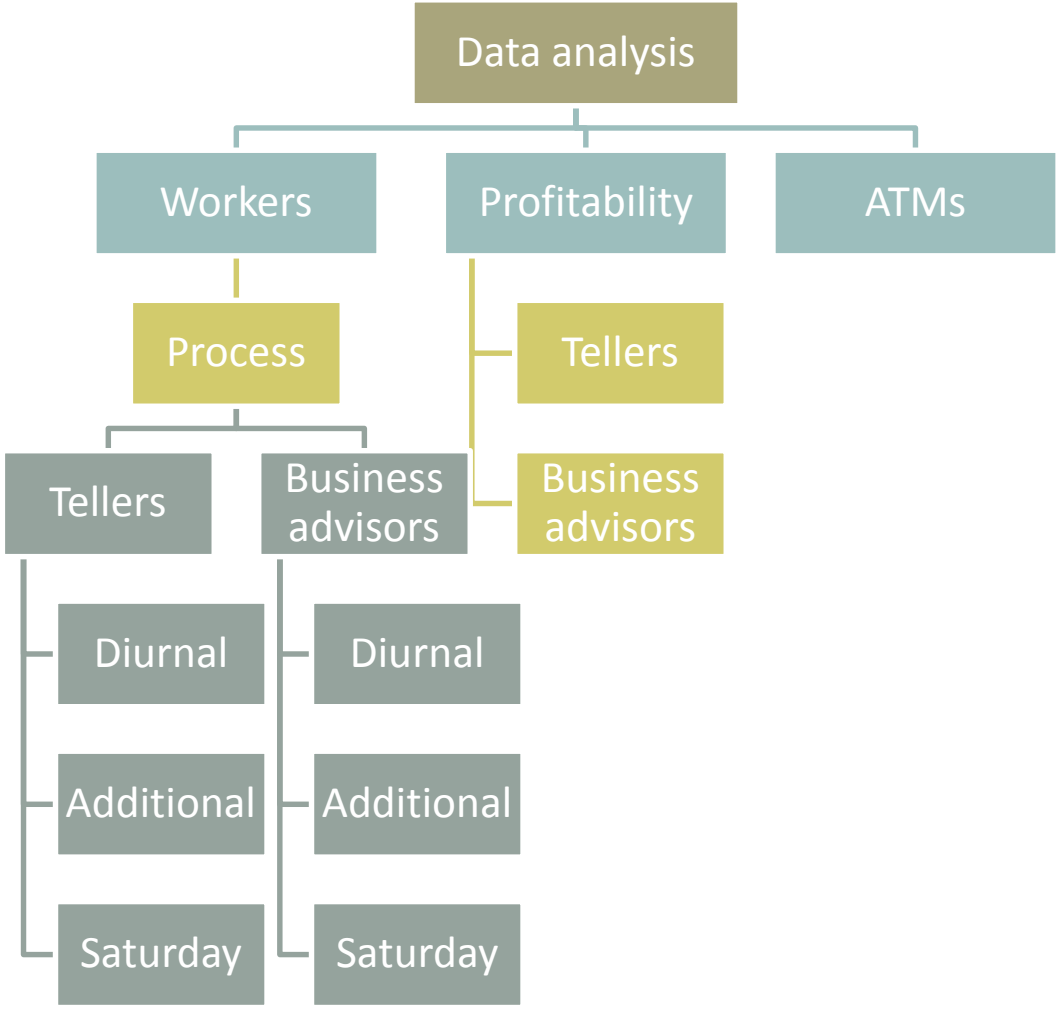
Methodology

Software



Methodology

Data analysis strategy



Model parameters

Methodology

Model parameters

Workstations installed, number of workers and ATMs (initial)

Position	Shift	Locations installed	Current workers	ATMs
Tellers	Diurnal	265	253	120
	Additional		88	
	Saturday		103	
Business advisors	Diurnal	283	248	
	Additional		102	
	Saturday		81	

Available time in hours per month (workers and ATMs)

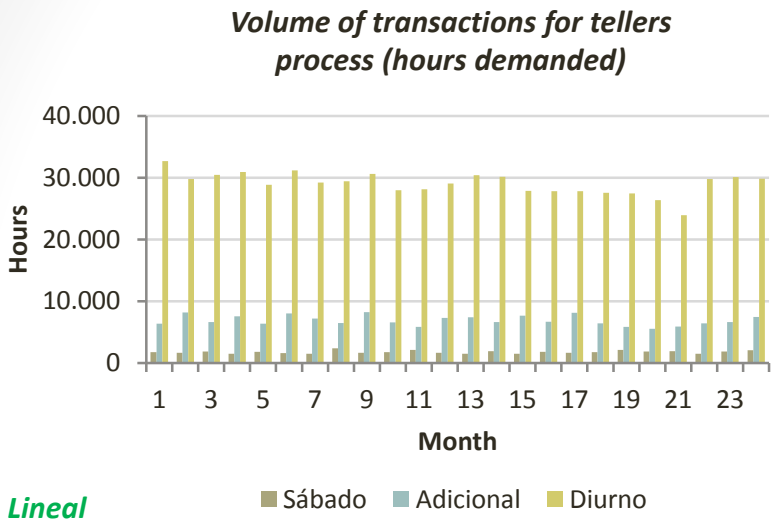
Type	Shift	Hours / Day	Supplements (%) – Provisioning (hrs)	Days / Month	Available time (Hours / Month)
Workers	Diurnal	6.45	0.11	20	114.72
	Additional	4.37		20	77.80
	Saturday	4.94		4	17.58
ATMs	All day	12.00	0.45	30	346.50

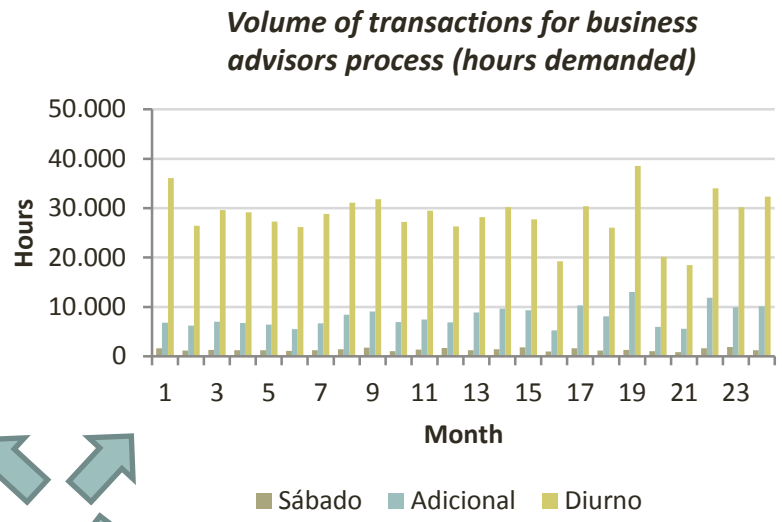
Delays and time review

Type	Setting	Delays (Month)	Time review (Month)
Workers	Hiring	2	3
	Dismissal	1	3
ATMs	Assembly	2	3
	Disassembly	1	3

Model parameters

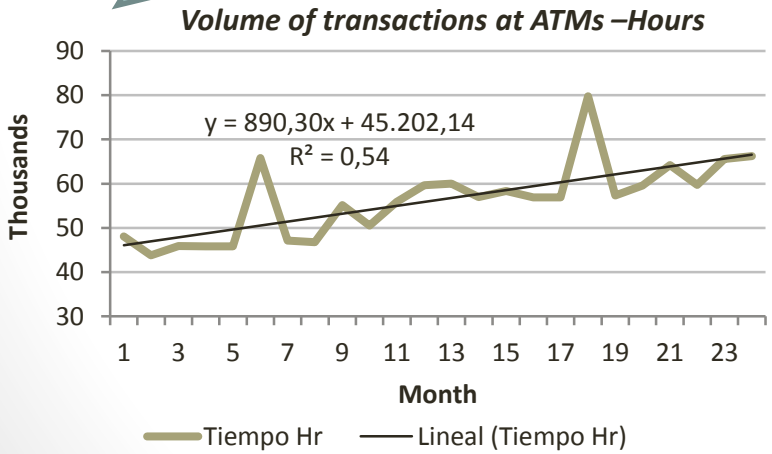
Historical data

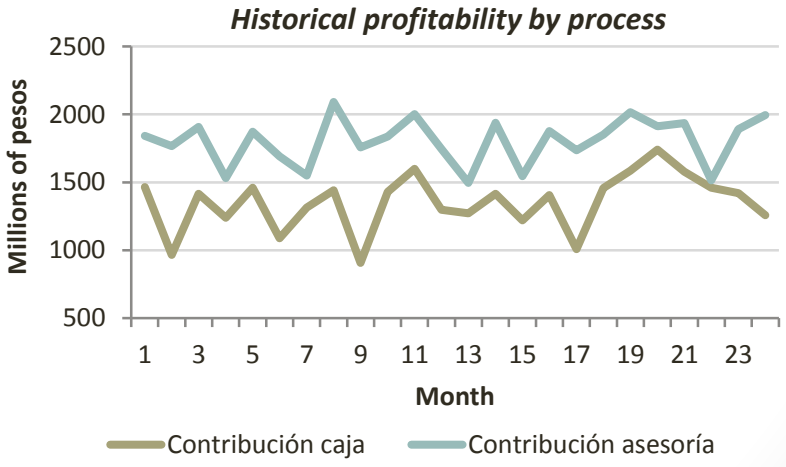




Lineal

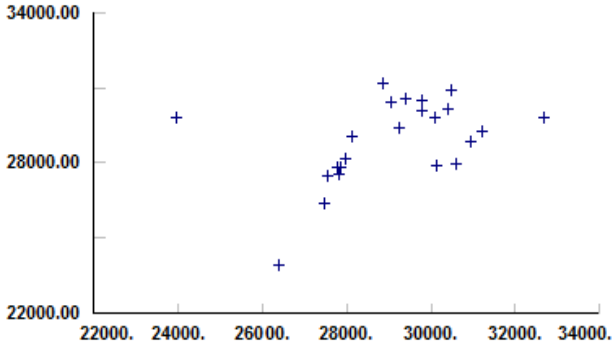
Probability density function



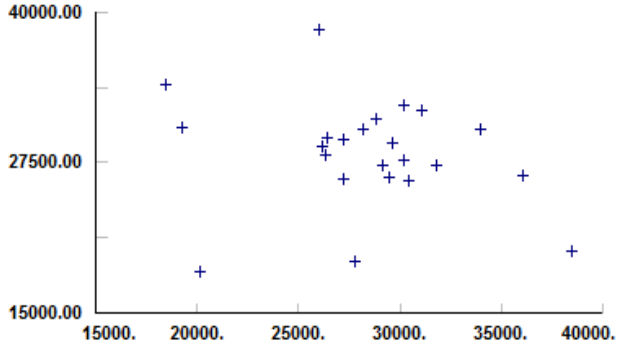


Goodness of fit

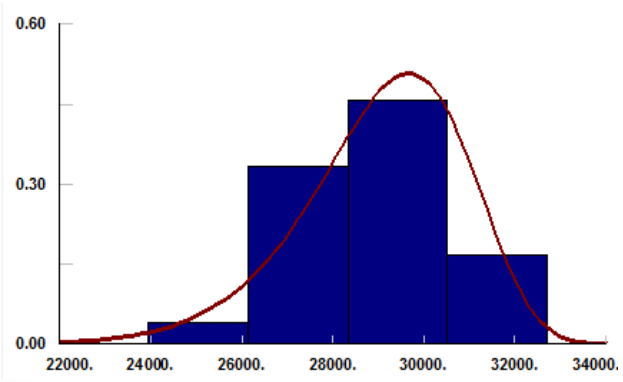
Scatter – Tellers transactions – Diurnal Shift



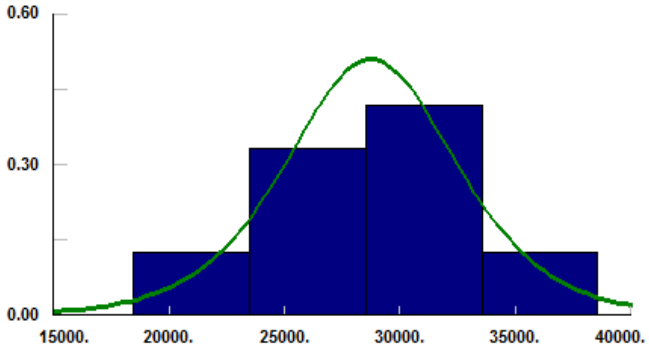
Scatter – Business Advisors transactions – Diurnal Shift



Fit – Tellers transactions – Diurnal Shift



Fit – Business Advisors transactions – Diurnal Shift



Fuente: Ésta investigación.

Independence

Statistical tests for independence – transactional demand

Position	Shift	Above/Below median	Turning points
Tellers	Diurnal	1.66969	1.8462
	Additional	0.417424	0.839181
	Saturday	1.25227	0.671345
Business advisors	Diurnal	0.834847	0.335673
	Additional	1.25227	0.335673
	Saturday	1.25227	0.839181

Statistical tests for independence – profitability by process

Process	Above/Below median	Turning points
Tellers	0.417424	0.839181
Business advisor	1.25227	0.671345

Density function

Density functions and parameters – transactional demand

Position	Shift	Distribution	Minimum	Maximum	Mode	Alfa	Beta	p	q	
Tellers	Diurnal	Weibull	13491.50	-	-	10.26	16332.60	-	-	
	Additional	Triangular	5353.53	8791.61	6405.32	-	-	-	-	
	Saturday	Beta	1457.24	2747.13	-	-	-	1.25	3.64	
Position	Shift	Distribution	Minimum	Lambda	Gamma	Delta	Alfa	Beta	p	q
Business advisors	Diurnal	Logistic	-	-	-	-	28741.00	2460.66	-	-
	Additional	Johnson SB	5112.72	8640.12	0.66	0.72	-	-	-	-
	Saturday	Pearson 6	873.96	-	-	-	-	1699.77	3.73	13.55

Density functions and parameters – profitability by process

Process	Distribution	Tau	Beta	Minimum	Maximum	Mode
Tellers	Triangular	-	-	8.25020E+08	1.79207E+09	1.44164E+09
Business advisor	Extreme Value	1.88758E+09	1.35397E+08	-	-	-

Capacity analysis

Capacity analysis

- ***Necessary Capacity*** **(Cn_{ijk})*:*** number of hours demanded for the process *i*, in the shift *j* and the month *k*, equal to transactional demand in hours per process and shift per month (d_{ijk}), results of the input of variables.

- ***Available capacity*** **(Cd_{ijk})*:*** number of hours available according to the time available for the process *i*, in the shift *j*, by the month *k* and the number of workers allocated.

- ***Discrepancy Capacity*** **(DS_{ijk})*:*** difference between the Available Capacity (Cd_{ijk}) and the Necessary Capacity (Cn_{ijk}) or transactional demand (d_{ijk}).

Capacity analysis

- **Available time in** hours for the process *i*, in the shift *j*, by the month *k* (Td_{ijk})

$$Td_{ijk} = h_j \times (1 - S) \quad (1)$$

Where:

- h_j: number of working hours in the shift *j*.
- *S*: Percentage of supplements established by the ILO (International Labour Organization).

Capacity analysis

- **Available capacity** for the process *i*, in the shift *j*, by the month *k* (Cd_{ijk}):

$$Cd_{ijk} = Td_{ijk} \times dm \times F_{ijk} \qquad (2)$$

Where:

- *dm*: days worked for the month.
- F_{ijk}: workers allocated process *i*, in the shift *j*, by the month *k*.

Capacity analysis

- ***Shortage Capacity (Cf_{ijk}):*** percentage of shortage capacity given in the case that transactional demand (d_{ijk}) exceeds the available capacity (Cd_{ijk}).

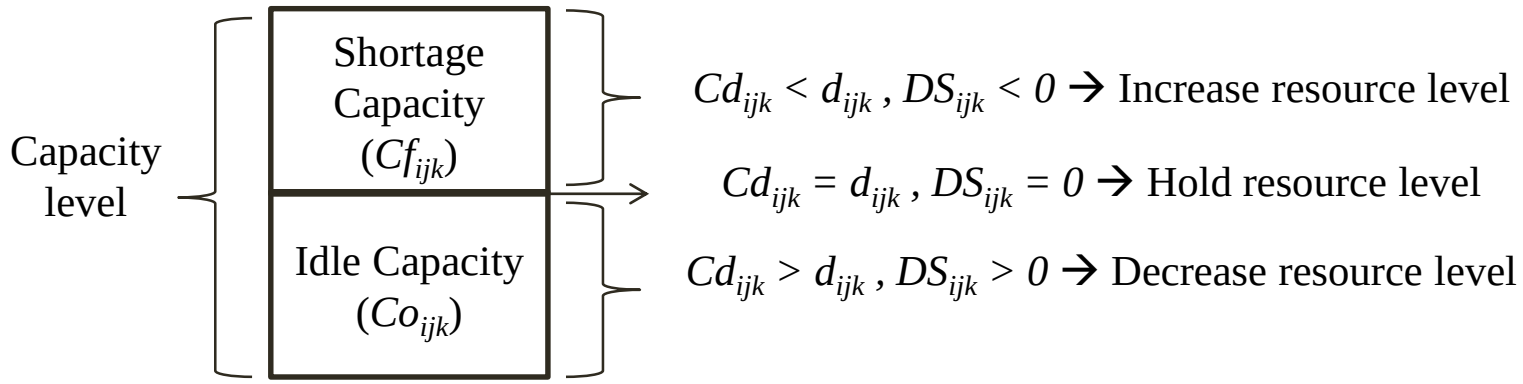
$$Cf_{ijk} = \begin{cases} \left(\frac{d_{ijk} - Cd_{ijk}}{Cd_{ijk}}\right) \times 100, & Cd_{ijk} < d_{ijk} \\ 0 \quad , & \text{otherwise} \end{cases} \qquad (3)$$

- ***Idle Capacity (Co_{ijk}):*** percentage of shortage capacity given in the case that the available capacity (Cd_{ijk}) exceeds the transactional demand (d_{ijk}).

$$Co_{ijk} = \begin{cases} \left(\frac{Cd_{ijk} - d_{ijk}}{Cd_{ijk}}\right) \times 100, & Cd_{ijk} > d_{ijk} \\ 0 \quad , & \text{otherwise} \end{cases} \qquad (4)$$

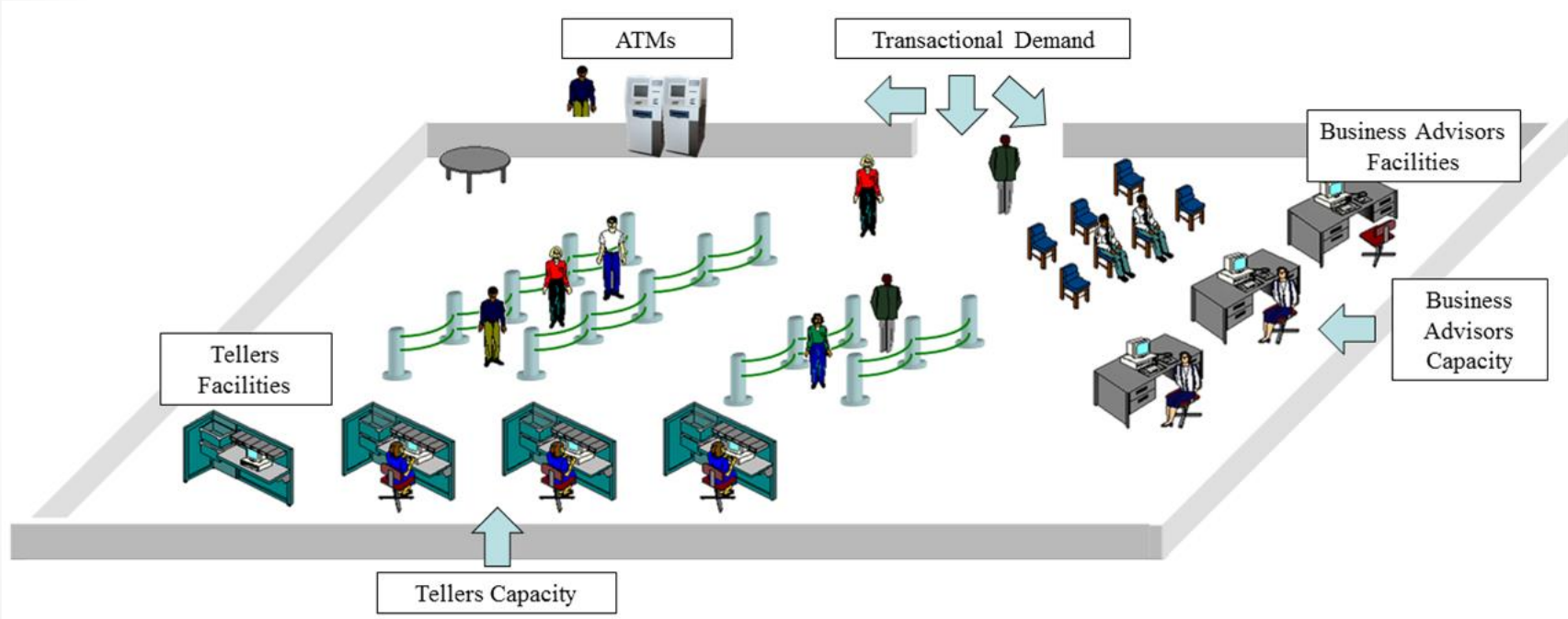
Capacity analysis

- Graphical analysis of the capabilities and allocation.



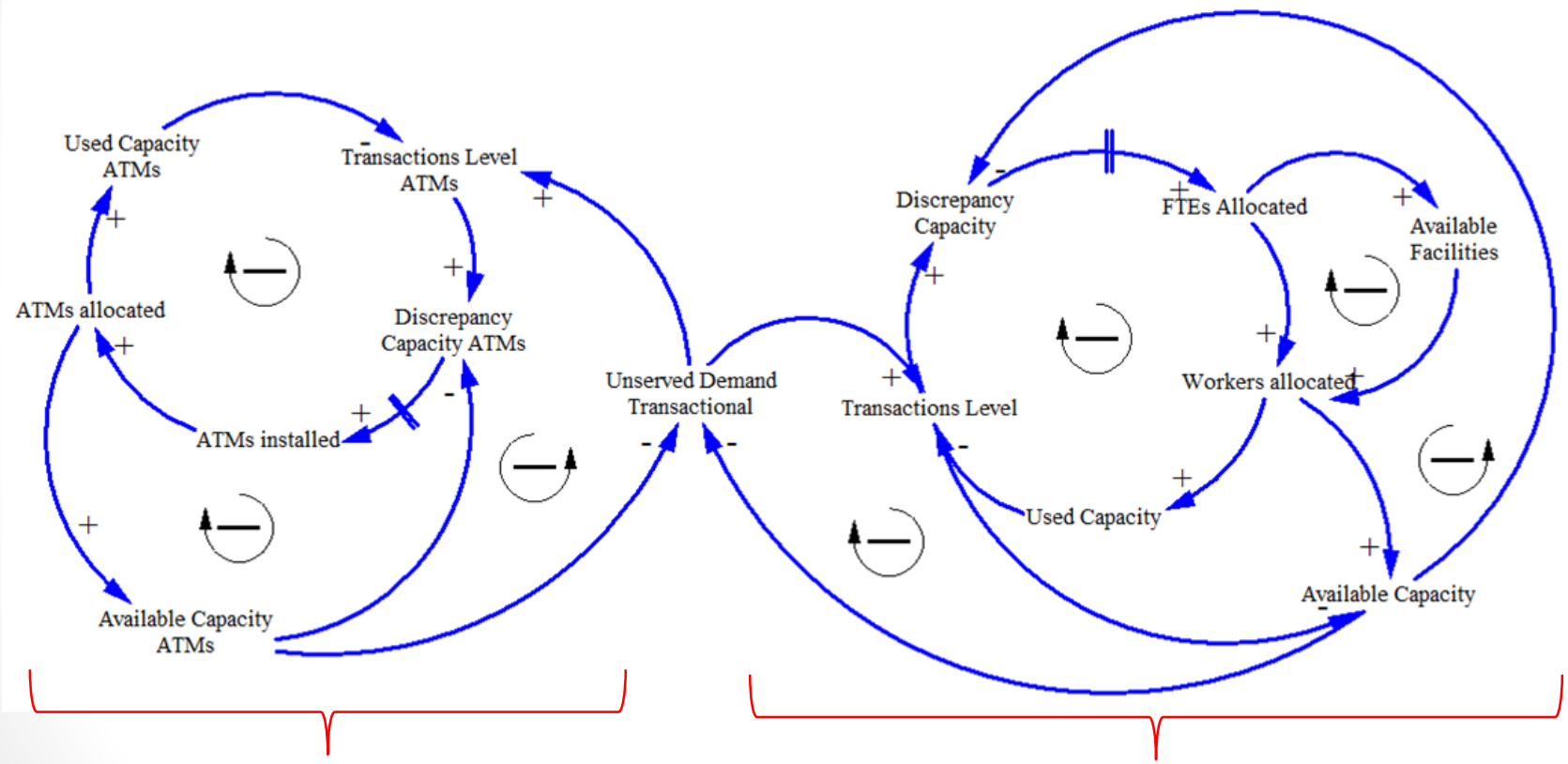
Model

Model conceptualization

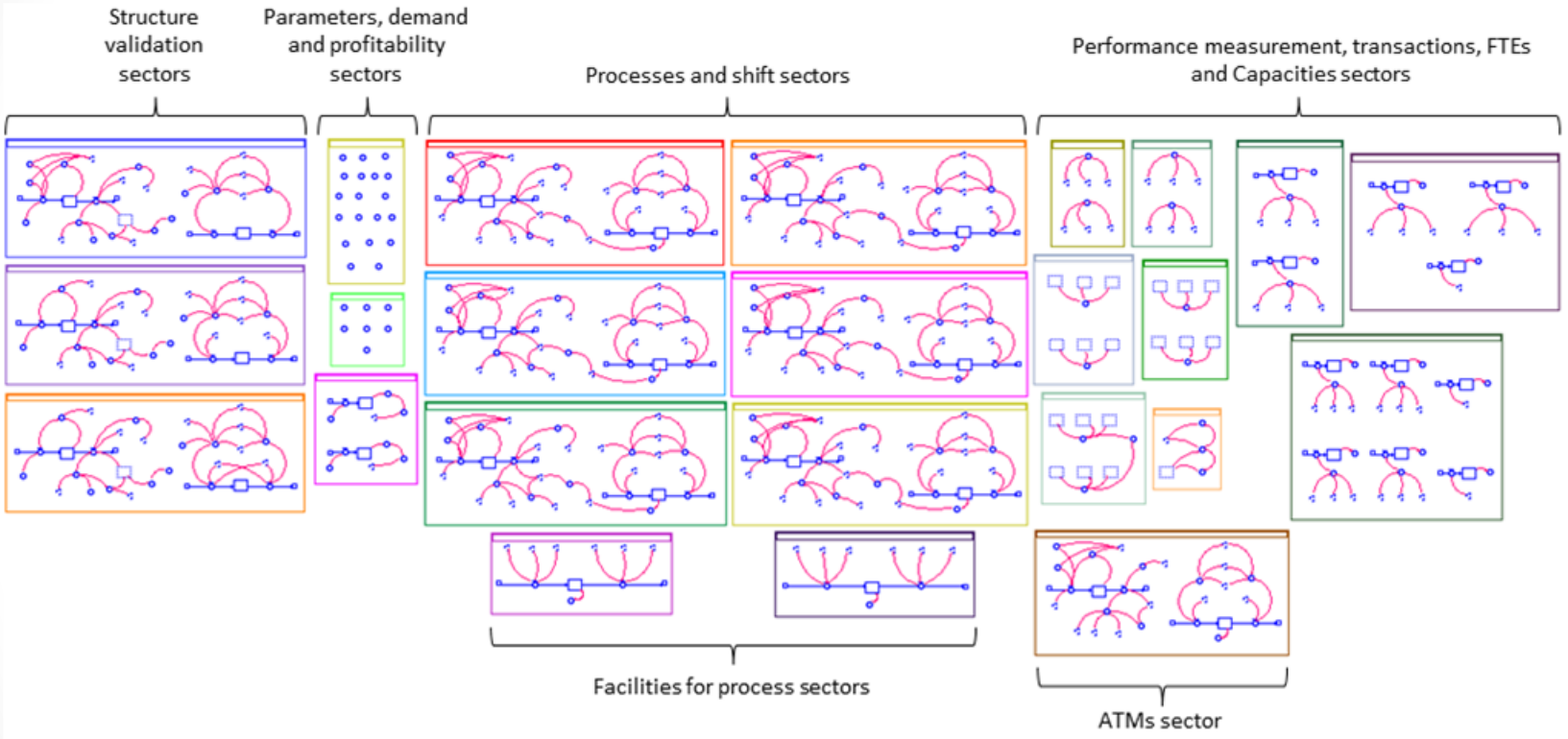


Model conceptualization

Causal model diagram

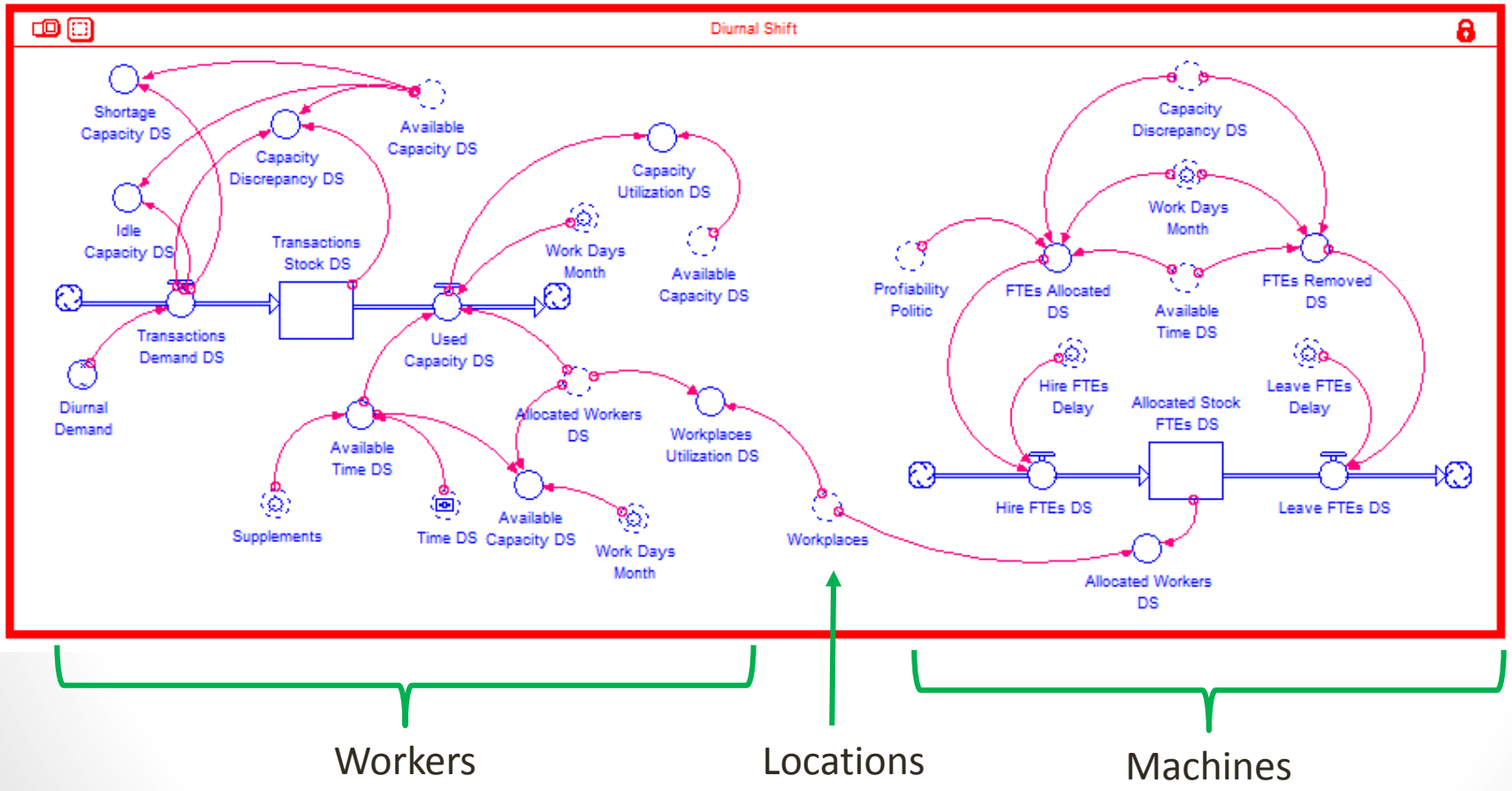


Model sectors



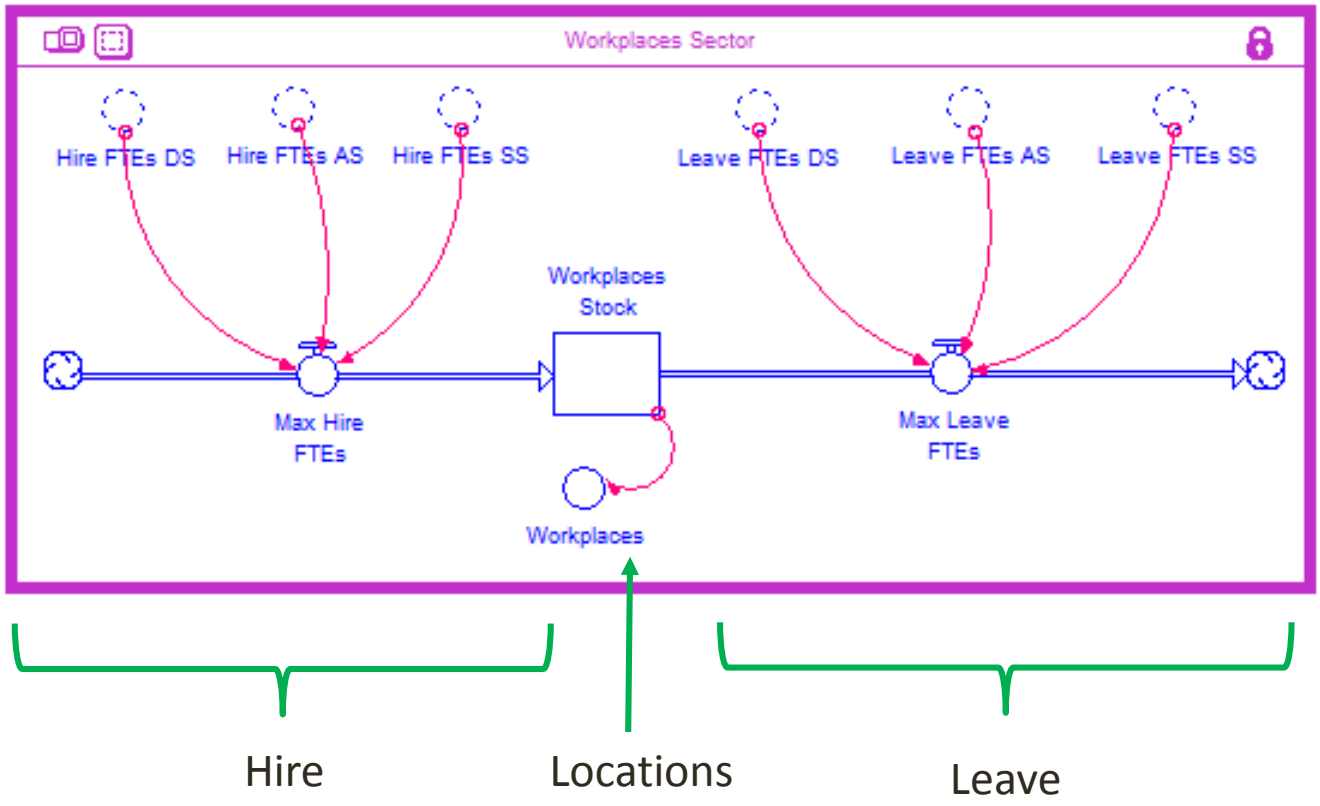
Sectors per process and shift

Forrester diagram for one of the process and shift sectors



Workstations per process sectors

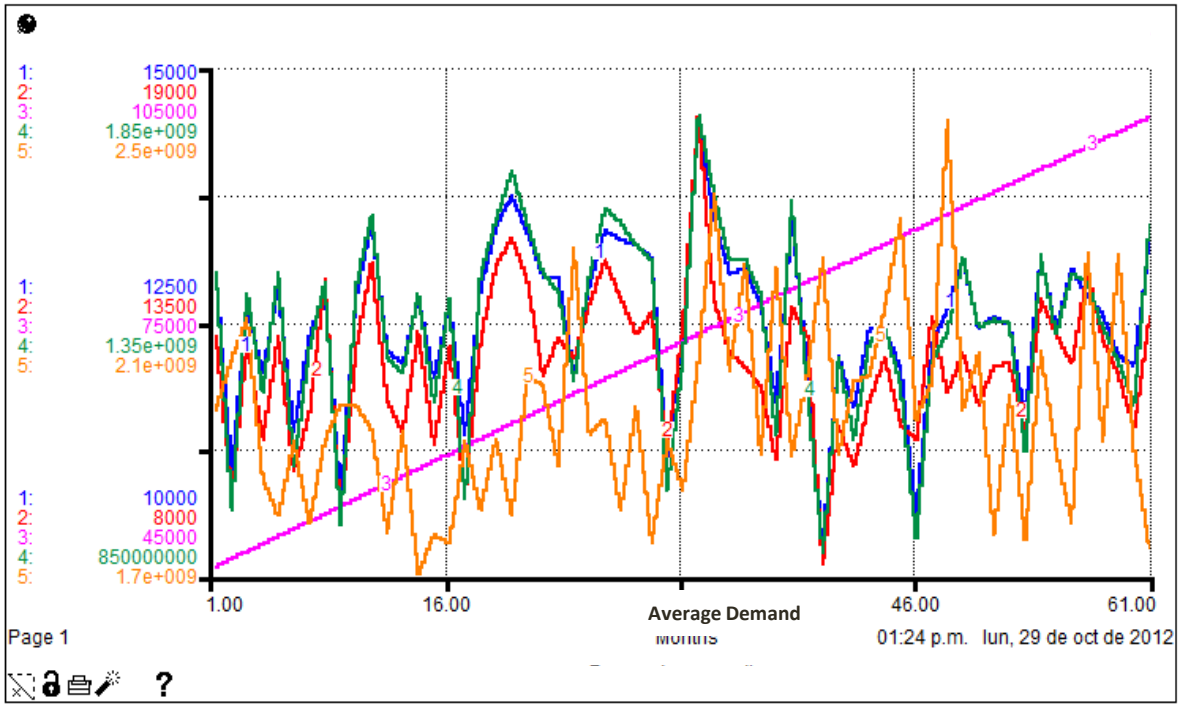
Forrester diagram for one of the workstations sectors



Model results

Behavior model input data

Input data



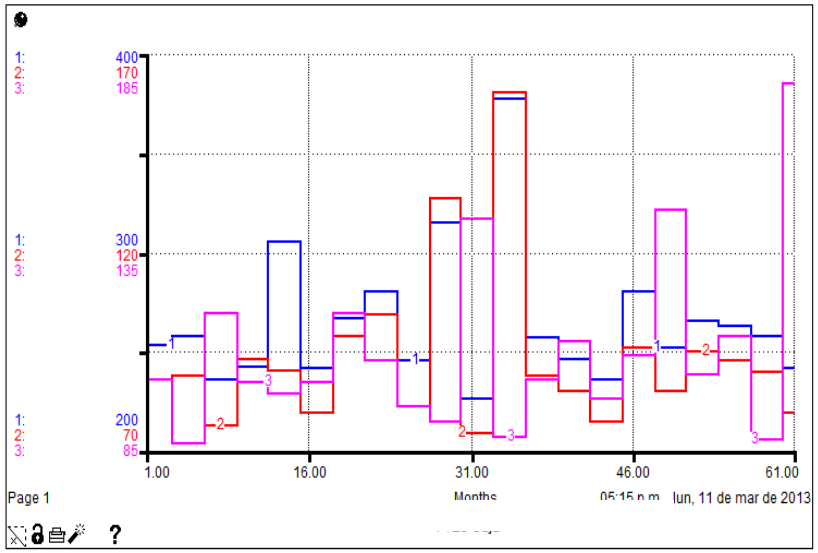
- ***Demand average - Tellers***
- ***Demand average - Business advisor***
- ***Demand - ATMs***
- ***Profitability - Tellers***
- ***Profitability - Business advisor***

Model

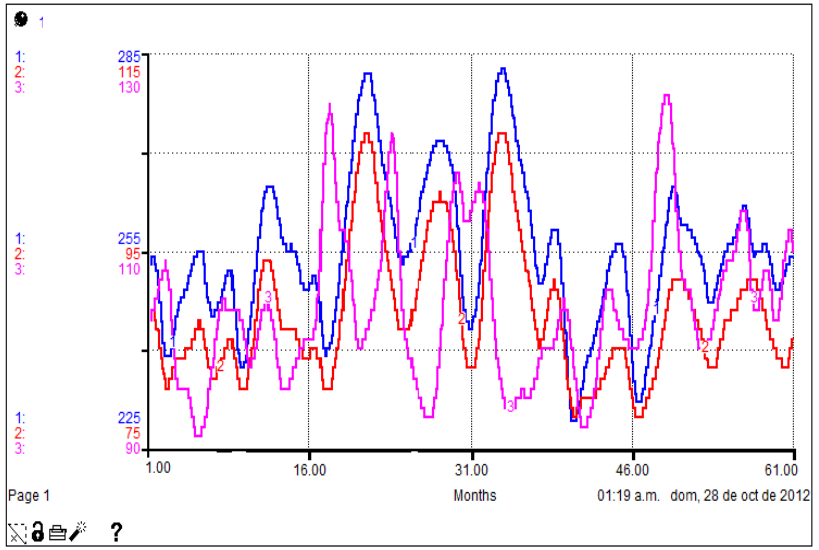
Workers per process

Tellers allocation per shift and scenario

Periodic Review



Continuous Review

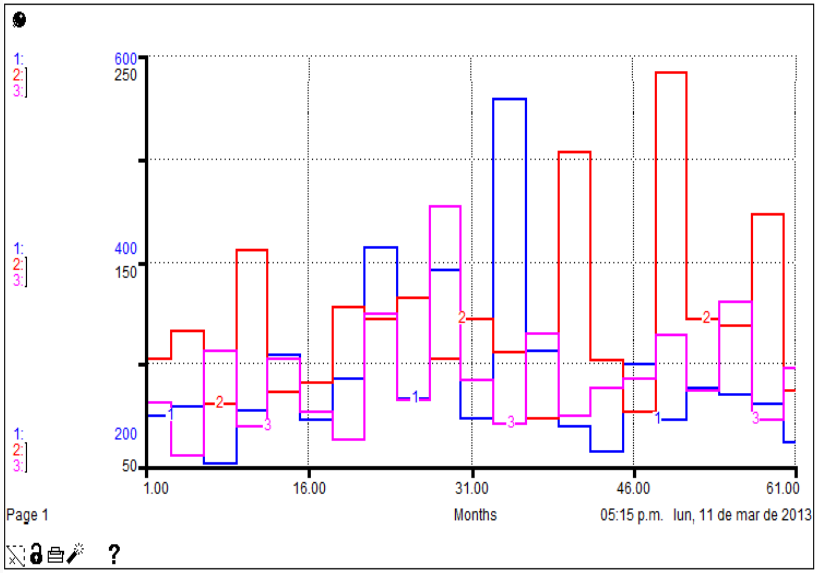


- ***Tellers - Day shift***
- ***Tellers - Additional Shift***
- ***Tellers - Saturday Shift***

Workers per process

Business advisors allocation per shift and scenario

Periodic Review



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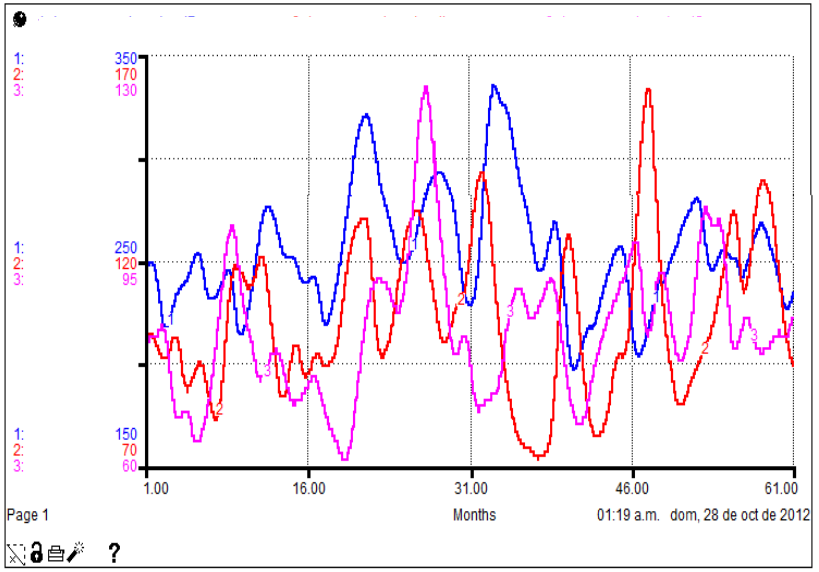
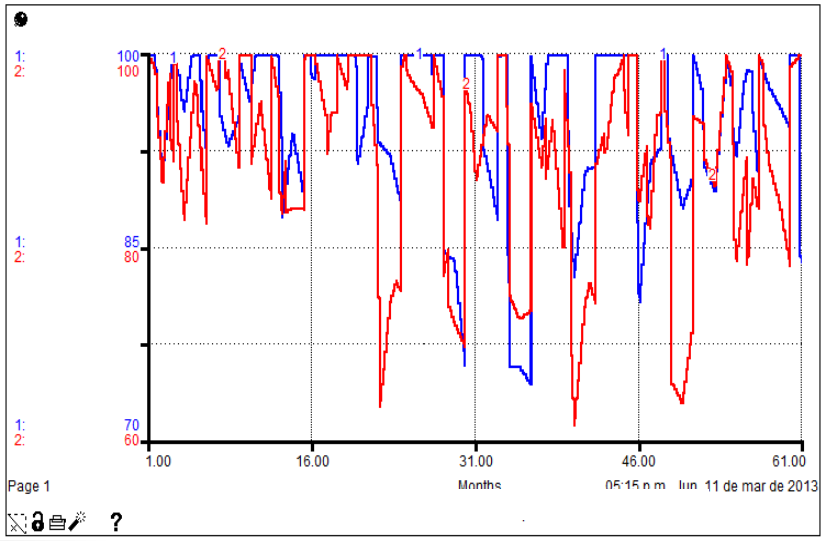


- ***Business advisors - Day shift***
- ***Business advisors - Additional shift***
- ***Business advisors - Saturday shift***

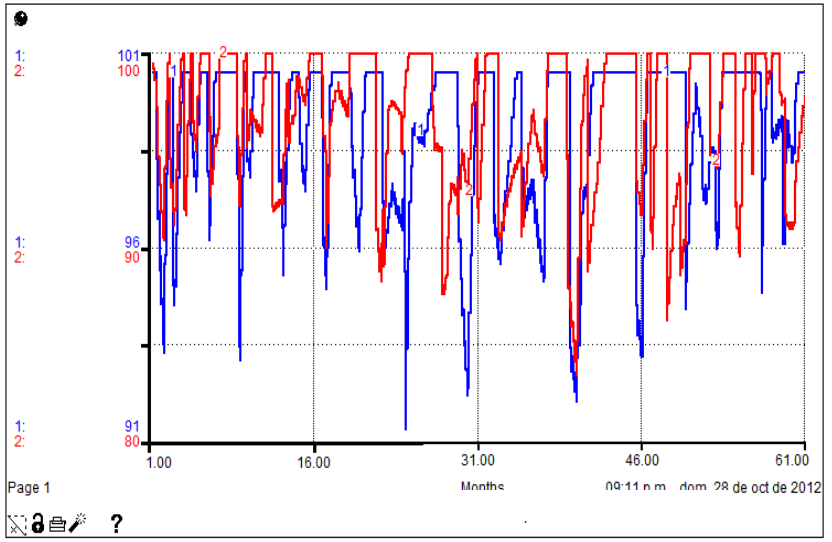
Average utilization of the available capacity

Average utilization of the available capacity per process

Periodic Review



Continuous Review



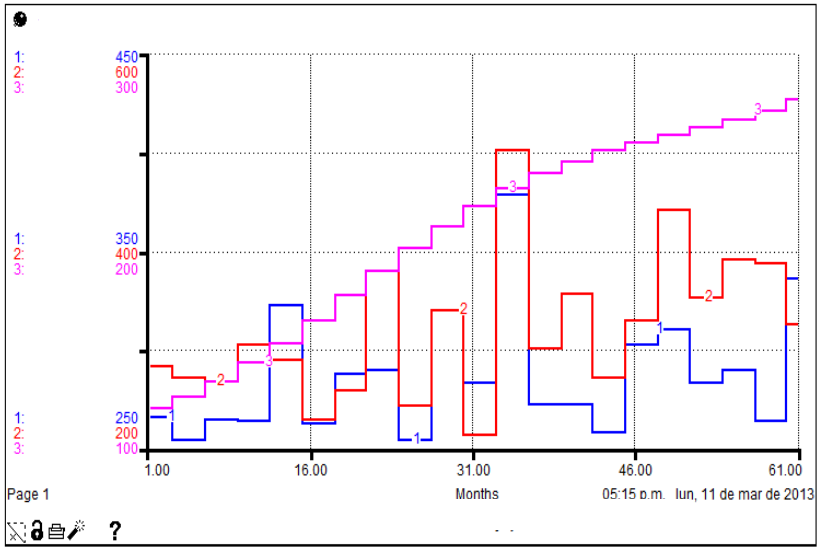
- ***Average Utilization of the available capacity Tellers***
- ***Average Utilization of the available capacity Business advisors***

Model

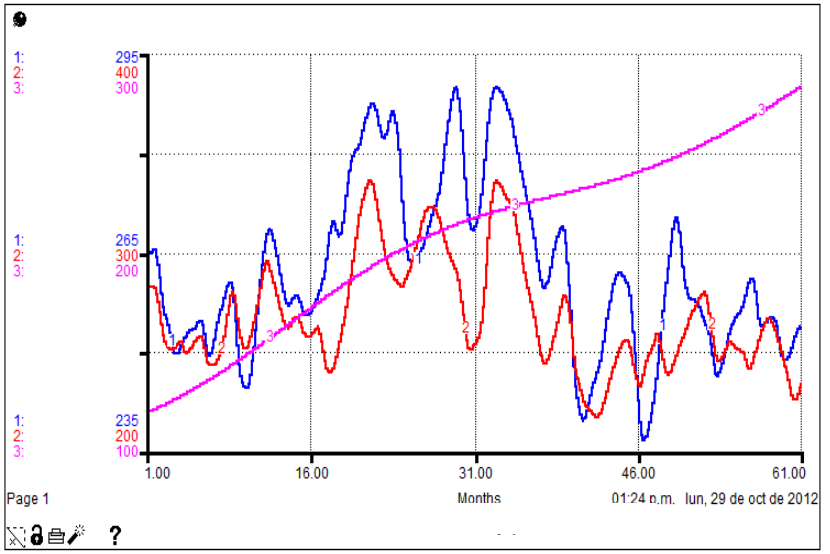
Facilities (ATMs and workstations per process)

Facilities (ATMs and workstations per process)

Periodic Review



Continuous Review



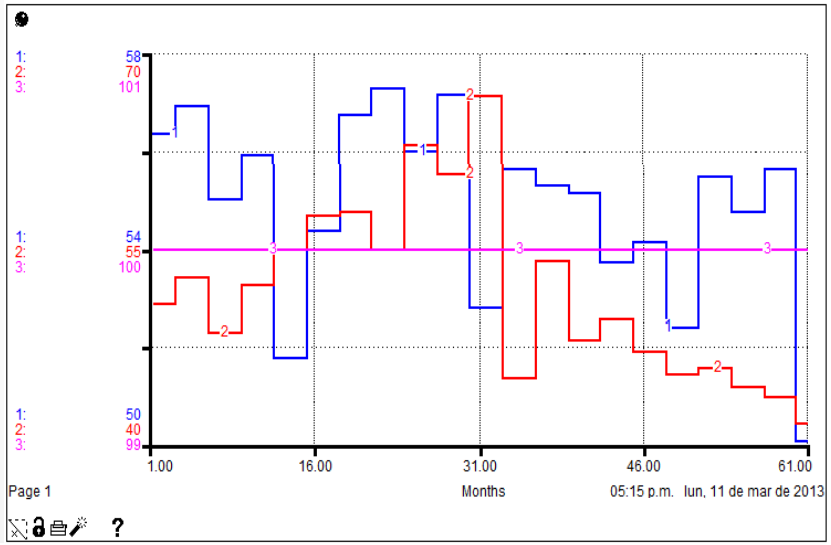
- ***Number of workstations - Tellers***
- ***Number of workstations - Business advisors***
- ***Installed ATMs***

Model

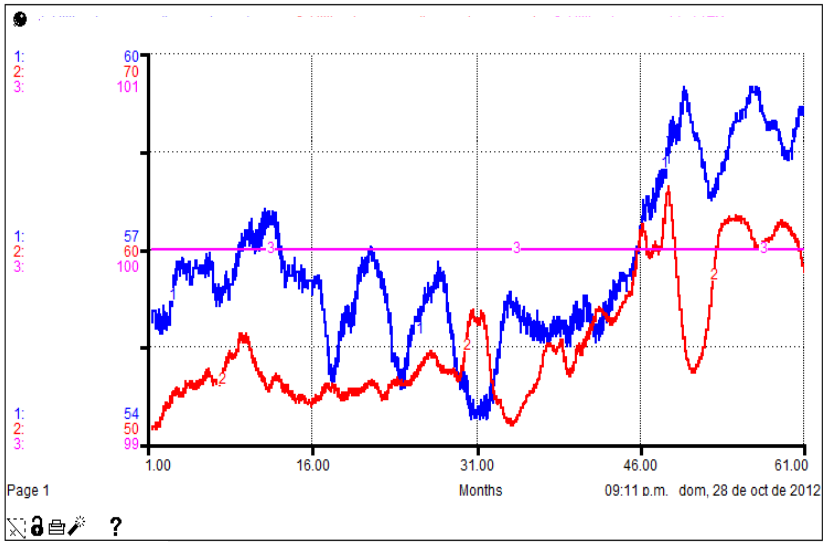
Available capacity utilization of the facilities

Available capacity utilization of the facilities (ATMs and workstations per process)

Periodic Review



Continuous Review



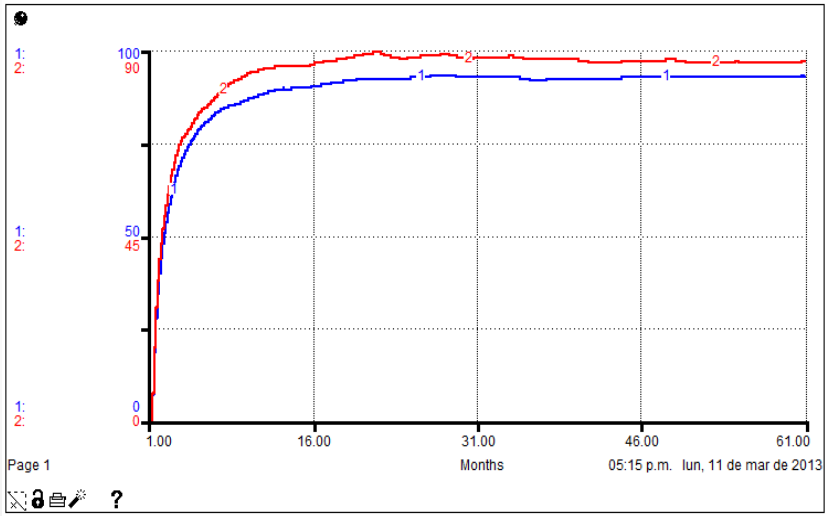
- Average capacity utilization *Tellers*
- ***Average capacity utilization Business advisors***
- *Capacity Utilization ATMs*

Model

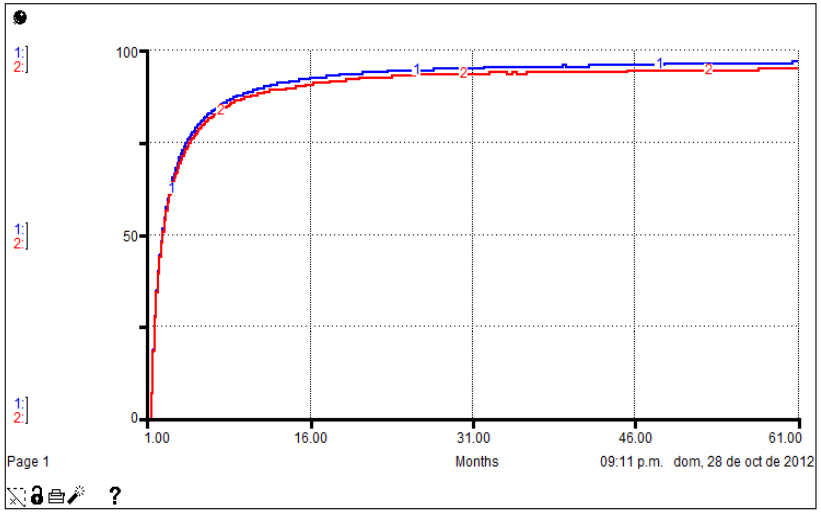
Convergence of the available capacity utilization (workers)

Convergence of the available capacity utilization per process

Periodic Review



Continuous Review



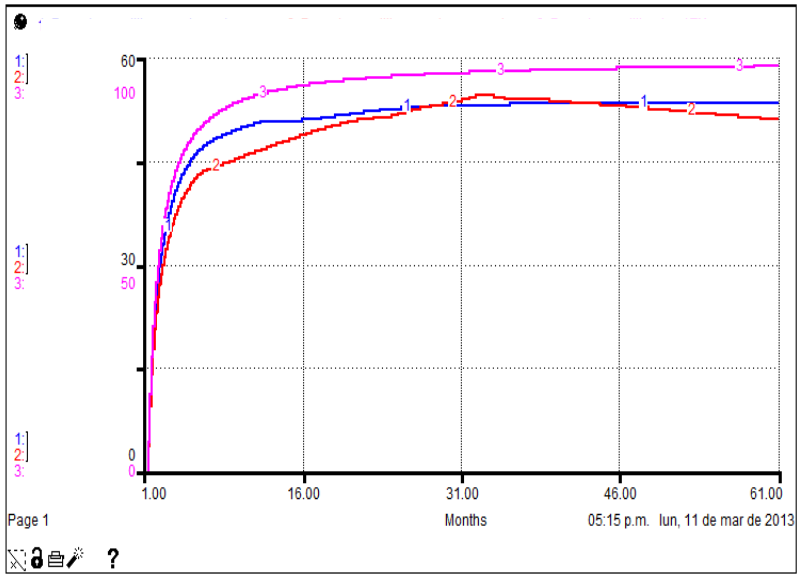
- Average capacity utilization - *Tellers*
- ***Average capacity utilization - Business advisors***

Model

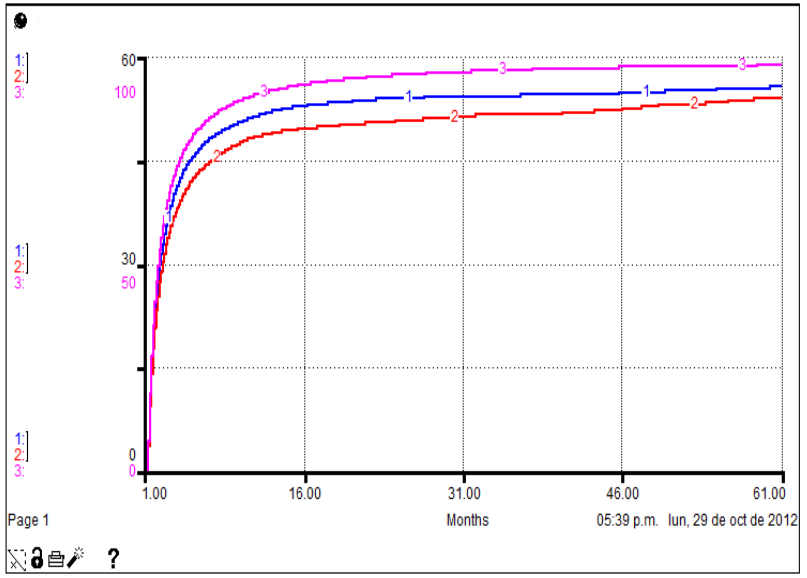
Convergence of the available capacity utilization (ATMs)

Convergence of the available capacity utilization (ATMs and workstations per process)

Periodic Review



Continuous Review



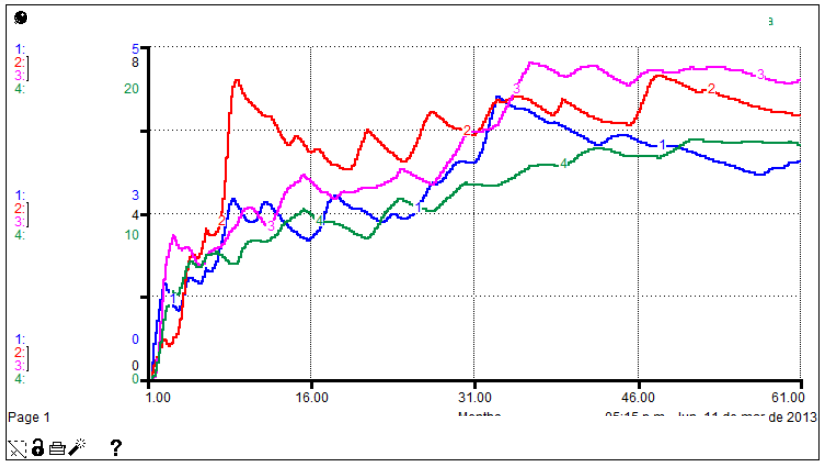
- ***Tellers workstations***
- ***Business advisors workstations***
- ***Average capacity utilization***

Model

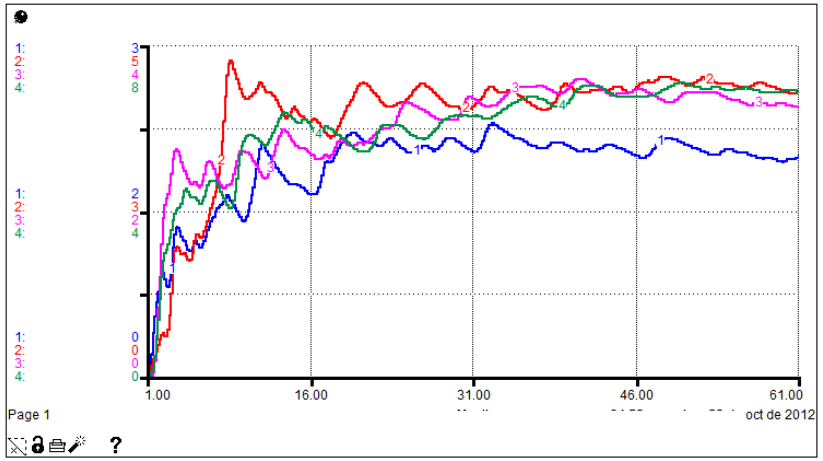
Convergence of shortage and idle capacity (workers allocated)

Convergence of shortage and idle capacity (workers allocated)

Periodic Review



Continuous Review



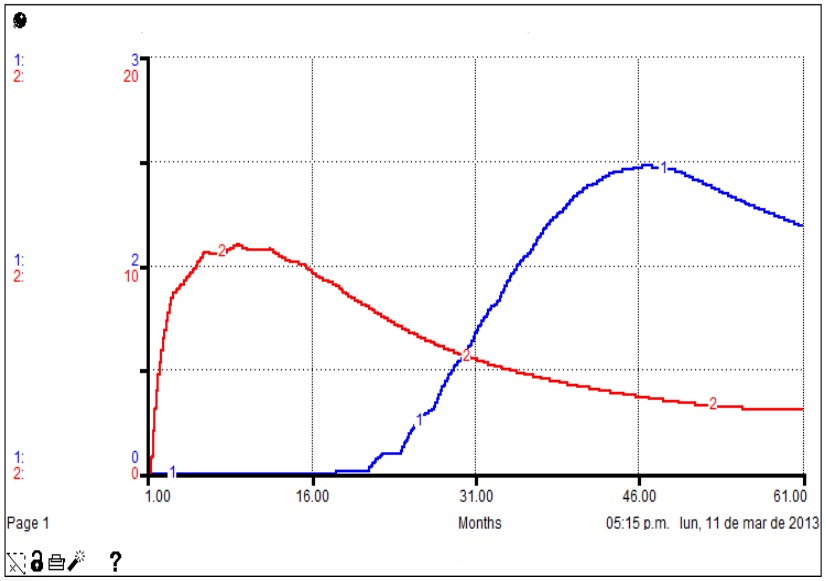
- ***Tellers - Shortage Capacity***
- ***Business advisors - Shortage Capacity***
- ***Tellers - Idle Capacity***
- ***Business advisors – Idle Capacity***

Model

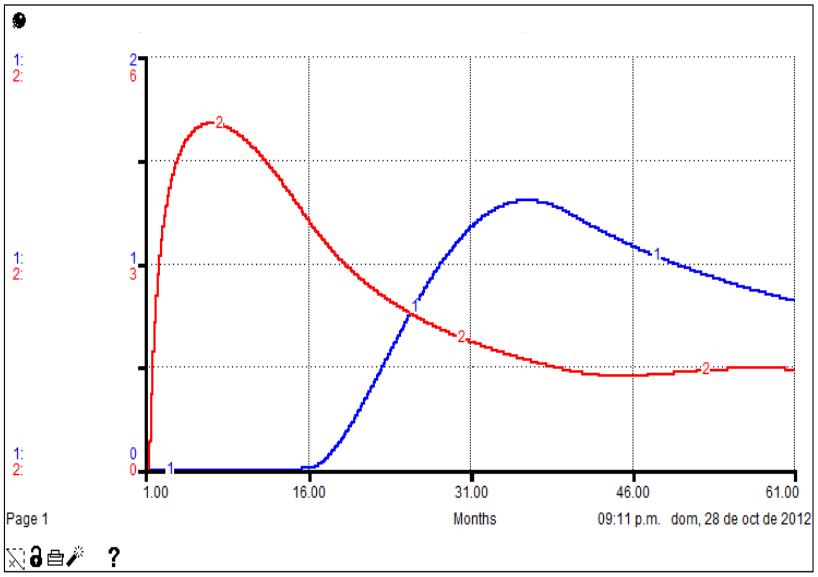
Convergence of shortage and idle capacity (ATMs)

Convergence of shortage and idle capacity (ATMs)

Periodic Review



Continuous Review



- Accumulated average Idle Capacity ATMs
- Accumulated average Shortage Capacity ATMs

Conclusions

Conclusions

- In the last twenty years the **service industry has exponentially increased** its trade balance in billions of dollars

- The models applied to the study of the capabilities **not fully considering the components included in this research**,
  - specifically analyzing the behavior of workers allocated per processes (tellers and business advisers) and shift (diurnal, additional and Saturday),

- Using generators with random variables identified, it was possible to simulate the behavior of a planning horizon longer (60 months),
  - which affected the **fluctuating levels of resource allocation** generated by the model,
  - considering delays and search for the **maximum use of available capacity**.

Conclusions

- Identifying and calculating abilities involved in the modeling, it was possible to compare the behavior of the model, which means finding the **best configuration in resource allocation**,
  - aims to maximize the use of available capacity, reducing the other hand percentages of missing capacity and idle capacity.

- Under the proposed scheme can detect staffing requirements, job requirements and **installation of ATMs**,

- The model is proposed for the analysis of operational capabilities in service companies that **include human resources and facilities**

Future work

Future work

- *Future work on the model developed, will focus on the study of the effect on employment generation:*
- increased electronic transactions,
- analyzing requirements for new skills of the workforce,
- the effect on salaries,
- customer service requirements and facilities for the service and,
- a profitability extended model.

¡Thank you very much!

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