Digital Appendix and Research Data for “A Taxonomy and Archetypes of Business Analytics in Smart Manufacturing”

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Appendix A – Bibliography (n=904)

Table A.1: Overview of Survey Publications (*n*=39)

References	Iteration
(Bang, Ak, Narayanan, Lee, & Cho, 2019; Baum, Laroque, Oeser, Skoogh, & Subramaniyan, 2018; Bordeleau, Mosconi, & Santa-Eulalia, 2018; Bousdekis, Magoutas, Mentzas, & (2018), 2015; Çaliş & Bulkan, 2015; Cardin et al., 2017; Cerrada et al., 2018; Y. Cheng, Chen, Sun, Zhang, & Tao, 2018; Diez-Olivan, Del Ser, Galar, & Sierra, 2019; Fay & Kazantsev, 2018; Gölzer, Cato, & Amberg, 2015; Gölzer & Fritzsche, 2017; Khan & Yairi, 2018; D.-H. Kim et al., 2018; S. L. Kumar, 2017; Y.-H. Kuo & Kusiak, 2018; G. Y. Lee et al., 2018; J. Lee, Wu, et al., 2014; Yaguo Lei et al., 2018; O'Donovan, Leahy, Bruton, & O'Sullivan, 2015; Precup, Angelov, Costa, & Sayed-Mouchaweh, 2015; Priore, Gómez, Pino, & Rosillo, 2014; M. S. Reis & Gins, 2017; Sharp, Ak, & Hedberg, 2018; Sutharssan, Stoyanov, Bailey, & Yin, 2015; T. Wuest, Weimer, Irgens, & Thoben, 2016; X. Y. Xu & Hua, 2017; Y. Xu, Sun, Wan, Liu, & Song, 2017; Zarandi, Asl, Sotudian, & Castillo, 2018b; G. Zhao, Zhang, Ge, & Liu, 2016; Y. Zhou & Xue, 2018; Zschech, 2018)	**Initial Literature Survey (*n*=32)**
(Cadavid, Lamouri, Grabot, Pellerin, & Fortin, 2020; Dalzochio et al., 2020; H. Ding et al., 2020; Dowdeswell, Sinha, & MacDonell, 2020; Nath, Udmale, & Singh, 2020; W. Zhang, Yang, & Wang, 2019; Zonta et al., 2020)	**Second Literature Survey (*n*=7)**

Table A.2 Coded Publications from Initial Literature Survey with Clusters (*n*=633)[1]

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
1	(Abbasi, Lim, Rosli, Ismail, & Ibrahim, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
2	(Adly, Yoo, Muhaidat, & Al-Hammadi, 2014)	Quality Control	Descriptive	Cost; Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Classification; Clustering	1
3	(Afshari & Peng, 2015)	Design Analysis	Predictive	Customer Satisfaction	Customer	End-to-End	Historical/ Batch	Regression	6
4	(Agarwal & Shivpuri, 2015)	Quality Control	Predictive	Conformance; Customer Satisfaction	Process; Product; Reference	Horizontal	Real-time	Custom Development	1
5	(Amarnath, Sugumaran, & Kumar, 2013)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
6	(Aqlan, Saha, & Ramakrishnan, 2015)	Quality Control	Predictive	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Classification; Clustering	1
7	(Arabzad, Ghorbani, Razmi, & Shirouyehzad, 2015)	-	Prescriptive	Time; Cost	Process; ERP	No Integration	Historical/ Batch	Fuzzy Logic	-
8	(Arık & Toksarı, 2018)	Production Planning	Prescriptive	Time; Cost	Process; ERP	No Integration	Historical/ Batch	Mathematical Optimization	2
9	(Aydın, Karaköse, & Akın, 2015)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Fuzzy Logic	5
10	(O. Aydin & Guldamlasioglu, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
11	(Azadeh, Seif, Sheikhalishahi, & Yazdani, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
12	(Bagheri, Yang, Kao, & Lee, 2015)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	6
13	(Balogun & Mativenga, 2013)	Energy Cons. Analysis	Predictive	Cost; Sustainability	Machine/ Tool; Process	No Integration	Historical/ Batch	Custom Development	6
14	(Bastani, Barazandeh, & Kong, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	5
15	(Bastania, Rao, & Zhenyu, 2016)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	Horizontal	Real-time	Classification	3
16	(Bauza et al., 2018)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Custom Development	1
17	(Benmoussa & Djeziri, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Clustering	4
18	(Besenhard, Scheibelhofer, François, Joksch, & Kavsek, 2018)	Monitoring	Diagnostic	Time; Cost	Process	Horizontal	Real-time	Custom Development	3
19	(Bevilacqua, Ciarapica,	Energy Cons. Analysis	Descriptive	Cost; Sustainability	Machine/ Tool	Vertical	Real-time	Custom Development	3

[1] 11 references could not be coded for function and were excluded from clustering as outlined in the paper.

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
	Diamantini, & Potena, 2017)								
20	(Bink & Zschech, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Clustering	6
21	(Borgi, Hidri, Neef, & Naceur, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Regression	4
22	(Bouazza, Sallez, & Beldjilali, 2017)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; ERP	Vertical	Historical/ Batch	Reinforcement Learning	2
23	(Bulnes, Usamentiaga, Garcia, & Molleda, 2016)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Product	No Integration	Real-time	Clustering	1
24	(Bumblauskas, Gemmill, Igou, & Anzengruber, 2017)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	2
25	(Bustillo, Urbikain, Perez, Pereira, & Lopez de Lacalle, 2018)	Quality Opt.	Prescriptive	Conformance; Customer Satisfaction	Machine/ Tool	No Integration	Historical/ Batch	Classification; Regression	1
26	(Cachada et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Deep Learning	3
27	(B. Cai, Liu, & Xie, 2016)	Monitoring	Diagnostic	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Probabilistic Methods	5
28	(Canito et al., 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
29	(Carbery, Woods, & Marshall, 2018)	Quality Control	Predictive	Conformance; Customer Satisfaction	Process; Product	No Integration	Historical/ Batch	Probabilistic Methods	1
30	(Caricato & Grieco, 2017)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; ERP	Vertical; Horizontal	Historical/ Batch	Mathematical Optimization	2
31	(Chaki, Bathe, Ghosal, & Padmanabham, 2018)	Quality Opt.	Prescriptive	Conformance; Customer Satisfaction	Machine/ Tool; Human	Vertical; Horizontal	Real-time	Mathematical Optimization	1
32	(Chakravorti et al., 2018)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool; Human	Vertical; Horizontal	Real-time	Custom Development	3
33	(Chamnanlor, Sethanan, Gen, & Chien, 2017)	Production Planning	Prescriptive	Time; Cost	Process; ERP	No Integration	Historical/ Batch	Evolutional Algorithm; Swarm Intelligence	2
34	(B. Chen & Chang, 2017)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
35	(Chong Chen, Liu, Kumar, & Qin, 2018)	Energy Cons. Analysis	Predictive	Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
36	(Y. Chen, Jin, & Jiri, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
37	(Yiwei Cheng, Zhu, Wu, & Shao, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Clustering; Deep Learning	6
38	(Chiang, Jiang, Zhu, Huang, & Braatz, 2015)	Monitoring	Diagnostic	Time; Cost	Process	No Integration	Real-time	Custom Development	3
39	(C.-F. Chien, Chang, & Wang, 2014)	Performance Analysis	Diagnostic	Time; Cost	Machine/ Tool; Process	No Integration	Historical/ Batch	Regression	6
40	(C.-F. Chien, Diaz, & Lan, 2014)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Classification	3
41	(C.-F. Chien, C.-Y. Hsu, & P.-N. Chen, 2013)	Monitoring	Descriptive	Time; Cost	Process	Vertical	Real-time	Classification; Clustering	3
42	(C. Chien et al., 2018)	-	Prescriptive	Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Regression	-
43	(S. Cho et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
44	(J.-H. Choi, Lee, Jung, & Cho, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Probabilistic Methods; Clustering	4
45	(Chou & Su, 2017)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Classification	1
46	(Codjo, Jaafar, Makich, Knittel, & Nouari, 2018)	Quality Control	Predictive	Conformance; Customer Satisfaction	Machine/ Tool; Product	No Integration	Real-time	Classification	1
47	(Conde et al., 2018)	Quality Opt.	Prescriptive	Conformance; Customer Satisfaction	Machine/ Tool	No Integration	Historical/ Batch	Classification; Mathematical Optimization	1
48	(D'Addona, Ullah, & Matarazzo, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
49	(da Silva, Gabbar, Junior, & da Costa Junior, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
50	(Demetgul, Yildiz, Taskin, Tansel, & Yazicioglu, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Dimension Reduction	5
51	(Deutsch, He, & He, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
52	(K. Ding & Jiang, 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3
53	(Domova & Dagnino, 2017)	Security/ Risk Analysis	Diagnostic	Security	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
54	(Dou & Zhou, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
55	(Emec, Krüger, & Seliger, 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
56	(Fan, Zhu, Kuo, Lu, & Wu, 2017)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Custom Development	3
57	(Fink, Zio, & Weidmann, 2014)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
58	(Fumagalli, Macchi, Colace, Rondi, & Alfieri, 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
59	(Gan & Wang, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
60	(Giannetti & Ransing, 2016)	Performanc e Analysis	Predictive	Conformance; Customer Satisfaction	Process	Vertical	Historical/ Batch	Regression	3
61	(Goryachev et al., 2013)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; ERP; Human	Vertical	Real-time	Multi-Agent System	2
62	(Granados, Lacroix, & Medjaher, 2018)	Quality Control	Predictive	Conformance	Process	No Integration	Real-time	Custom Development	1
63	(Gröger, Kassner, et al., 2016)	Performanc e Opt.	Predictive	Time; Cost		Vertical; Horizontal	Real-time	Custom Development	3
64	(Gugulothu et al., 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
65	(L. Guo, Lei, Xing, Yan, & Li, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
66	(L. Guo, Li, Jia, Lei, & Lin, 2017)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
67	(Z. Guo, Ngai, Yang, & Liang, 2015)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; ERP; Human	Vertical; Horizontal	Real-time	Mathematical Optimization	2
68	(D. Han, Zhao, & Shi, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Deep Learning	5
69	(Y. He, Zhu, He, Gu, & Cui, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool; Process; Product	No Integration	Real-time	Custom Development	4
70	(Y. He et al., 2017)	Quality Control	Diagnostic	Conformance; Customer Satisfaction	Product; Customer	End-to-End	Historical/ Batch	Custom Development	1
71	(Heger, Hildebrandt, & Scholz-Reiter, 2015)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; ERP	No Integration	Historical/ Batch	Regression	2
72	(Hseush, Huang, Hsu, & Pu, 2013)	Production Planning	Descriptive	Time; Cost	ERP	Vertical; Horizontal	Real-time	Custom Development	3
73	(Chao-Yung Hsu, Kang, & Weng, 2016)	Quality Control	Predictive	Conformance; Customer Satisfaction	Product	No Integration	Real-time	Classification	1
74	(J. Hu, Lewis, Gan, Phua, & Aw, 2014)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Probabilistic Methods	3
75	(S. Hu, Zhao, Yao, & Dou, 2016)	Monitoring	Diagnostic	Time; Cost	Process	Vertical	Real-time	Classification; Swarm Intelligence	3
76	(D. Huang, Lin, Chen, & Sze, 2018)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Machine/ Tool	Vertical	Historical/ Batch	Deep Learning	1
77	(Hur et al., 2015)	Performanc e Analysis	Predictive	Time; Cost	Process; Human	No Integration	Historical/ Batch	Regression	6
78	(Ivanov, Dolgui, Sokolov, Werner, & Ivanova, 2016)	Production Planning	Prescriptive	Time; Cost	Process; ERP	No Integration	Historical/ Batch	Mathematical Optimization	2
79	(A. K. Jain & Lad, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool; Product	No Integration	Real-time	Classification	4
80	(S. Jain, Lechevalier, & Narayanan, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
81	(V. Jain, Kundu, Chan, & Patel, 2015)	-	Prescriptive	Time; Cost	ERP	Horizontal	Historical/ Batch	Swarm Intelligence	-
82	(Javed, Gouriveau, Li, & Zerhouni, 2018)	Performanc e Analysis	Predictive	Time; Cost	Process; Product	No Integration	Historical/ Batch	Regression	6
83	(Ji-Hyeong & Su-Young, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
84	(W. Ji & Wang, 2017)	Monitoring	Predictive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Classification	3
85	(F. Jia, Lei, Lin, Zhou, & Lu, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
86	(J. Jiang & Kuo, 2017)	Design Analysis	Diagnostic	Customer Satisfaction	Product; Customer	End-to-End	Historical/ Batch	Classification	6
87	(Y. Jiao, Yang, Zhong, & Zhang, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
88	(Jing, Ma, Hu, Zhu, & Chen, 2018)	Quality Control	Predictive	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Swarm Intelligence	1
89	(Jung, Tsai, Chiu, Hu, & Sun, 2018)	Quality Control	Diagnostic	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Deep Learning	1

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
90	(Kadar, Jardim-Gonçalves, Covaciu, & Bullon, 2017)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Product	No Integration	Real-time	Classification	1
91	(Karabadji, Seridi, Khelf, Azizi, & Boulkroune, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
92	(Kashkoush & ElMaraghy, 2017)	Production Planning	Prescriptive	Time; Cost	Process; Product	Vertical; Horizontal	Historical/ Batch	Mathematical Optimization	2
93	(Kaur, Selway, Grossmann, Stumptner, & Johnston, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
94	(Khazaee et al., 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
95	(Kiangala & Wang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
96	(Kibira & Shao, 2017)	Energy Cons. Opt.	Prescriptive	Cost; Sustainability	Machine/ Tool	No Integration	Real-time	Mathematical Optimization	6
97	(A. Kim, Oh, Jung, & Kim, 2018)	Quality Control	Descriptive	Conformance	Machine/ Tool; Process	No Integration	Real-time	Classification	1
98	(M. S. Kim et al., 2018)	Quality Control	Diagnostic	Conformance; Customer Satisfaction	Product	No Integration	Real-time	Regression	1
99	(Kohlert & Konig, 2016)	Performance Opt.	Descriptive	Time; Cost	Machine/ Tool; Human	Vertical	Real-time	Classification	4
100	(Koulali, Koulali, Tembine, & Kobbane, 2018)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	2
101	(Dominik Kozjek, Kralj, & Butala, 2017)	Monitoring	Diagnostic	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Classification	3
102	(Dominik Kozjek, Rihtaršič, & Butala, 2018)	Production Planning	Predictive	Time; Cost	Process; Product	Vertical; Horizontal	Historical/ Batch	Classification	2
103	(D. Kozjek, Vrabic, Kralj, & Butala, 2017)	Monitoring	Diagnostic	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Classification	3
104	(Krumeich, Werth, & Loos, 2016)	Performance Opt.	Prescriptive	Time; Cost	Process	No Integration	Real-time	Custom Development	2
105	(Ajay Kumar, Shankar, Choudhary, & Thakur, 2016)	Monitoring	Diagnostic	Time; Cost	Machine/ Tool; Process	No Integration	Historical/ Batch	Classification	5
106	(Ajay Kumar, Shankar, & Thakur, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
107	(Kumaraguru & Morris, 2014)	Performance Analysis	Predictive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3
108	(Kumru & Kumru, 2014)	Performance Analysis	Predictive	Time; Cost		No Integration	Historical/ Batch	Classification	6
109	(Lachenmaier, Lasi, & Kemper, 2015)	Production Planning	Descriptive	Time; Cost	ERP	Vertical	Historical/ Batch	Custom Development	3
110	(Lade, Ghosh, & Srinivasan, 2017)	Quality Control	Diagnostic	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Custom Development	1
111	(P.-J. Lai & Wu, 2015)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Evolutional Algorithm; Swarm Intelligence	2
112	(S. Langarica, Rüffelmacher, & Núñez, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Dimension Reduction	4
113	(J. Lee, Jin, & Bagheri, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
114	(J. Y. Lee, Yoon, & Kim, 2017)	Quality Control	Descriptive	Conformance	Process; Product	Vertical	Real-time	Custom Development	3
115	(Legat & Vogel-Heuser, 2017)	Production Planning	Prescriptive	Time; Cost; Flexibility	Machine/ Tool; Process	Vertical	Historical/ Batch	Custom Development	2
116	(Yaguo Lei, Jia, Lin, Xing, & Ding, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
117	(Y Lei, Jia, Zhou, & Lin, 2015)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
118	(Yaguo Lei, Li, et al., 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
119	(Lesany, Koochakzadeh, & Fatemi Ghomi, 2014)	Monitoring	Descriptive	Conformance	Process	Horizontal	Real-time	Classification	3
120	(C. Li, R.-V. Sanchez, et al., 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
121	(C. Li, Tao, Ao, Yang, & Bai, 2018)	Energy Cons. Analysis	Predictive	Cost; Sustainability	Machine/ Tool	Vertical	Historical/ Batch	Regression	6
122	(Q. Li & S. Liang, 2018b)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
123	(T. Li, He, & Zhu, 2016)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Process; Customer	End-to-End	Historical/ Batch	Custom Development	1
124	(Xiang Li, Zhang, & Ding, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
125	(Liang, Lu, Li, & Wang, 2018)	-	Prescriptive	Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Swarm Intelligence	-
126	(Lim et al., 2016)	Production Planning	Prescriptive	Time; Cost	Process; ERP	No Integration	Historical/ Batch	Custom Development	2
127	(C. Lin et al., 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
128	(Changqing Liu, Li, Zhou, & Shen, 2018)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	5
129	(C Liu, Wang, & Li, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
130	(Yingfeng Zhang, Ren, Liu, & Si, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
131	(T.-I. Liu & Jolley, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
132	Liu, 2013 #3319}	Monitoring	Diagnostic	Time; Cost	Process	Horizontal	Historical/ Batch	Probabilistic Methods	3
133	(Z.-J. Lu, Xiang, Wu, & Gu, 2015)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Human	Vertical	Real-time	Custom Development	3
134	(Z.-J. Lu et al., 2015)	Quality Control	Predictive	Conformance; Customer Satisfaction	Process; Product	No Integration	Historical/ Batch	Classification; Evolutional Algorithm	1
135	(B. Luo, Wang, Liu, Li, & Peng, 2018)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
136	(Y. Lv & Lin, 2017)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; Customer; ERP	Vertical; Horizontal	Real-time	Fuzzy Logic	2
137	(H. Ma, Chu, Xue, & Chen, 2017)	Design Analysis	Prescriptive	Customer Satisfaction	Product; Customer	End-to-End	Historical/ Batch	Mathematical Optimization; Fuzzy Logic	6
138	(J. Ma, Kwak, & Kim, 2014)	Design Analysis	Predictive	Customer Satisfaction	Product; Customer	End-to-End	Historical/ Batch	Classification	6
139	(Maggipinto, Terzi, Masiero, Beghi, & Susto, 2018)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Deep Learning	1
140	(Manco et al., 2017)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
141	(Mileva Boshkoska, Bohanec, Boškoski, & Juričić, 2015)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Regression	1
142	(Milo, Roan, & Harris, 2015)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Classification	3
143	(Molka-Danielsen, Engelseth, & Wang, 2018)	Security/ Risk Analysis	Descriptive	Security	Environment	No Integration	Real-time	Custom Development	3
144	(Mourtzis, Vlachou, Milas, & Dimitrakopoulos, 2016)	Energy Cons. Analysis	Descriptive	Cost; Sustainability	Machine/ Tool	Vertical	Real-time	Custom Development	3
145	(Mulrennan et al., 2018)	Quality Control	Predictive	Conformance; Customer Satisfaction	Product	No Integration	Real-time	Custom Development	1
146	(Muralidhar et al., 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Custom Development	3
147	(Muralidharan & Sugumaran, 2013)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
148	(H. N. Nguyen, Kim, & Kim, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
149	(Nie & Wan, 2015)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression; Clustering	6
150	(Ning, Yu, & Huang, 2018)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	3
151	(Niu & Li, 2017)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Fuzzy Logic	5
152	(Noyel, Thomas, Thomas, & Charpentier, 2016)	Quality Control	Predictive	Time; Cost; Conformance	Process	No Integration	Historical/ Batch	Classification	1
153	(Shiyong Wang, Wan, Li, & Liu, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool; Process; Human	Vertical	Real-time	Custom Development	3
154	(Nyanteh, Srivastava, Edrington, & Cartes, 2013)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Swarm Intelligence	4
155	(Oh, Ransikarbum, Busogi, Kwon, & Kim, 2018)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Product	No Integration	Real-time	Classification	1
156	(Onel, Kieslich, Guzman, Floudas, & Pistikopoulos, 2018)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Classification	3
157	(Oses, Legarretaetxebarria, Quartulli, Garcia, & Serrano, 2016)	Energy Cons. Analysis	Predictive	Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
158	(Pandiyan, Caesarendra, Tjahjowidodo, & Tan, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Evolutional Algorithm	4

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
159	(Jiten Patel & Choi, 2014)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
160	(W. Peng, Ye, & Chen, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
161	(Pimenov, Bustillo, & Mikolajczyk, 2018)	Quality Control	Predictive	Conformance; Customer Satisfaction	Machine/ Tool	No Integration	Real-time	Classification; Regression	1
162	(Shuhui Qu, Wang, & Jasperneite, 2018)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Reinforcement Learning	2
163	(Ragab, Ouali, Yacout, & Osman, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
164	(Ragab, Yacout, Ouali, & Osman, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
165	(Ranjit et al., 2015)	Monitoring	Descriptive	Time; Cost	Process; Human	Horizontal	Real-time	Classification	3
166	(Lei Ren, Cui, Sun, & Cheng, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
167	(Lei Ren, Sun, Cui, & Zhang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
168	(Rivera Torres, Anido Rifón, & Serrano Mercado, 2018)	Production Planning	Predictive	Time; Cost	Process	No Integration	Real-time	Probabilistic Methods	6
169	(Rivera Torres, Serrano Mercado, & Anido Rifón, 2018)	Production Planning	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Probabilistic Methods	6
170	(J. J. Rodríguez, Quintana, Bustillo, & Ciurana, 2017)	Quality Control	Predictive	Conformance	Machine/ Tool	Vertical	Historical/ Batch	Classification	1
171	(Rødseth & Schjølberg, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
172	(Rødseth, Schjølberg, & Marhaug, 2017)	Condition Analysis	Predictive	Time; Cost		Vertical	Real-time	Deep Learning	3
173	(Rude, Adams, & Beling, 2018)	Performanc e Analysis	Descriptive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3
174	(Saez, Maturana, Barton, & Tilbury, 2018)	Performanc e Analysis	Diagnostic	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3
175	(Safizadeh & Latifi, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
176	(Saha, Aqlan, Lam, & Boldrin, 2016)	-	Prescriptive	Time; Cost	Customer; ERP	Horizontal	Real-time	Fuzzy Logic	-
177	(Saldivar, Goh, Chen, & Li, 2016)	Design Analysis	Prescriptive	Customer Satisfaction	Product; Customer	End-to-End	Real-time	Dimension Reduction; Mathematical Optimization	6
178	(Santhana Babu, Giridharan, Ramesh Narayanan, & Narayana Murty, 2016)	Quality Control	Predictive	Conformance; Customer Satisfaction	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	1
179	(Saucedo-Espinosa, Escalante, & Berrones, 2017)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
180	(Schuh, Prote, Luckert, & Hünnekes, 2017)	Production Planning	Prescriptive	Time; Cost	Process	No Integration	Historical/ Batch	Classification	2
181	(Shaban, Yacout, Balazinski, & Jemielniak, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
182	(H. Shao et al., 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
183	(J.-H. Shin, Kiritsis, & Xirouchakis, 2015)	Design Analysis	Diagnostic	Customer Satisfaction	Product	End-to-End	Real-time	Clustering	6
184	(Shiue, Lee, & Su, 2018)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Reinforcement Learning	2
185	(Soualhi, Razik, Clerc, & Doan, 2014)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Probabilistic Methods	6
186	(Spezzano & Vinci, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Clustering	4
187	(Sreenuch, Tsourdos, & Jennions, 2013)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical	Real-time	Classification	5
188	(Stefanovic, 2015)	-	Predictive	Time; Cost; Flexibility	ERP	Vertical	Historical/ Batch	Regression; Clustering	-
189	(Subramaniyan, Skoogh, Gopalakrishnan, Salomonsson, et al., 2016)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Classification	3
190	(Susto, Beghi, & McLoone, 2017)	Monitoring	Diagnostic	Time; Cost	Process	No Integration	Real-time	Classification	3

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
191	(Muhammad Syafrudin, Alfian, Fitriyani, & Rhee, 2018)	Monitoring	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Classification	3
192	(Somkiat Tangjitsitcharoen & Wongtangthinthan, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
193	(Tong, Teng, Sun, & Guan, 2018)	Performanc e Opt.	Prescriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Evolutional Algorithm	3
194	(Tristo, Bissacco, Lebar, & Valentinčič, 2015)	Energy Cons. Analysis	Descriptive	Cost; Sustainability	Machine/ Tool	No Integration	Real-time	Custom Development	3
195	(Trunzer et al., 2017)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
196	(Vafeiadis et al., 2018)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Classification	1
197	(Villalonga, Beruvides, Castaño, Haber, & Novo, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3
198	(Vrabic, Kozjek, & Butala, 2017)	Monitoring	Predictive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Classification	3
199	(Vununu, Moon, Lee, & Kwon, 2018)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
200	(Wan et al., 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool		Real-time	Classification	4
201	(Guofeng Wang, Guo, & Qian, 2014)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
202	(Guofeng Wang, Guo, & Yang, 2013)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
203	(Guofeng Wang, Liu, Cui, & Feng, 2014)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
204	(Guofeng Wang, Yang, Xie, & Zhang, 2014)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
205	(J. Wang et al., 2016)	Performanc e Opt.	Prescriptive	Time; Cost; Flexibility	Machine/ Tool; Process	Vertical	Real-time	Reinforcement Learning	2
206	(Shijin Wang & Liu, 2015)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; ERP	No Integration	Historical/ Batch	Mathematical Optimization	2
207	(Xiao Wang, Wang, & Qi, 2016)	Maintenanc e Planning	Prescriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Reinforcement Learning	2
208	(Yue Wang & Tseng, 2014)	Design Analysis	Diagnostic	Customer Satisfaction	Customer	End-to-End	Historical/ Batch	Custom Development	6
209	(Yi Wang, Xu, Liang, & Jiang, 2015)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Dimension Reduction	5
210	(Waschneck et al., 2018b)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; Customer; ERP	Vertical	Historical/ Batch	Deep Learning; Reinforcement Learning	2
211	(Wedel, von Hacht, Hieber, Metternich, & Abele, 2015)	Performanc e Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
212	(Weimer, Scholz-Reiter, & Shpitalni, 2016)	Quality Control	Descriptive	Conformance	Product	No Integration	Historical/ Batch	Deep Learning	1
213	(J. Wen, Gao, & Zhang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
214	(D. Wu et al., 2017)	Monitoring	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	3
215	(D. Z. Wu, Jennings, Terpenny, Gao, & Kumara, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
216	(J. Wu et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Fuzzy Logic	4
217	(W. Wu, Zheng, Chen, Wang, & Cao, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Probabilistic Methods	4
218	(Yuting Wu, Yuan, Dong, Lin, & Liu, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
219	(Thorsten Wuest, Irgens, & Thoben, 2014)	Quality Control	Descriptive	Conformance; Customer Satisfaction	Machine/ Tool; Process	No Integration	Real-time	Classification; Clustering	1
220	(Xanthopoulos, Kiatipis, Koulouriotis, & Stieger, 2018)	Maintenanc e Planning	Prescriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Reinforcement Learning	2
221	(Xiaoya Xu, Zhong, Wan, Yi, & Gao, 2016)	Security/ Risk Analysis	Descriptive	Security	Human	No Integration	Real-time	Custom Development	3
222	(Xun, Zhu, Zhang, Cui, & Xiong, 2018)	Security/ Risk Analysis	Descriptive	Security	Machine/ Tool	No Integration	Real-time	Classification	3
223	(H. H. Yan et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
224	(J. Yan, Meng, Lu, & Li, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
225	(Jun Yang, Zhou, Yang, Xu, & Hu, 2018)	Security/ Risk Analysis	Descriptive	Security	Machine/ Tool; Process	No Integration	Real-time	Custom Development	3
226	(W.-A. Yang, Zhou, Liao, & Guo, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Swarm Intelligence	4
227	(Z. Yang et al., 2018)	Monitoring	Predictive	Time; Cost	Process	No Integration	Historical/ Batch	Regression	6
228	(F. Yao et al., 2018)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process	Vertical; Horizontal	Real-time	Custom Development	2
229	(G. Yin, Zhang, Li, Ren, & Fan, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
230	(X. Yin, He, Niu, & Li, 2018)	Quality Opt.	Prescriptive	Conformance; Customer Satisfaction	Machine/ Tool; Process	No Integration	Real-time	Regression; Evolutional Algorithm	1
231	(Yuan, Zhang, & Duan, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
232	(Yunusa-Kaltungo & Sinha, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
233	(Yuwono et al., 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Clustering	5
234	(Zarei, Tajeddini, & Karimi, 2014)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
235	(C. Zhang, Lim, Qin, & Tan, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning; Evolutional Algorithm	6
236	(C. Zhang, Yan, Lee, & Shi, 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	Horizontal	Real-time	Dimension Reduction	3
237	(C. Zhang & Zhang, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
238	(J. Zhang, Ahmad, Vera, & Harrison, 2018)	Design Analysis	Predictive	Customer Satisfaction	Process; Product	End-to-End	Historical/ Batch	Custom Development	6
239	(L. Zhang, Gao, Dong, Fu, & Liu, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
240	(Xinmin Zhang, Kano, & Li, 2018)	Monitoring	Diagnostic	Time; Cost	Process	Horizontal	Real-time	Dimension Reduction	3
241	(Yingfeng Zhang, Ma, Yang, Lv, & Liu, 2018)	-	Prescriptive	Sustainability	Machine/ Tool; Process	Vertical; Horizontal	Real-time	Custom Development	-
242	(Z. J. Zhang & Zhang, 2015)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Regression	4
243	(L. Zhao, Yan, Wang, & Yao, 2018)	Monitoring	Descriptive	Time; Cost	Process	Horizontal	Real-time	Classification	3
244	(R. Zhao et al., 2018)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	5
245	(C. Zheng, Dai, Zhang, Hu, & Guo, 2017)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Classification	3
246	(H. Zheng, Feng, Gao, & Tan, 2018)	Performance Analysis	Predictive	Time; Cost; Conformance; Customer Satisfaction	Machine/ Tool; Process	Vertical	Real-time	Regression	3
247	(X. C. Zheng, Wang, & Ordieres-Mere, 2018)	Monitoring	Descriptive	Time; Cost; Security	Human	No Integration	Real-time	Deep Learning	6
248	(R. Zhong, Huang, Dai, & Zhang, 2014)	Production Planning	Diagnostic	Time; Cost; Flexibility	Process	Vertical	Real-time	Classification	2
249	(Ray Y Zhong, Wang, & Xu, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
250	(J. Zhu, Chen, & Peng, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Dimension Reduction	6
251	(K. Zhu & Liu, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Probabilistic Methods	4
252	(X. Zhu, Xiong, & Liang, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
253	(Ziani, Felkaoui, & Zegadi, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
254	(Zou, Xia, & Li, 2018)	Monitoring	Diagnostic	Time; Cost	Process	Horizontal	Historical/ Batch	Regression	3
255	(Zurita, Delgado, Carino, Ortega, & Clerc, 2016)	Production Planning	Predictive	Time; Cost	Process	Horizontal	Historical/ Batch	Fuzzy Logic	2
256	(Mrugalska, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Fuzzy Logic	6
257	(Kedadouche, Thomas, & Tahan, 2016)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
258	(C. Li, M. Cerrada, et al., 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Clustering; Fuzzy Logic	5
259	(Di, Song, Liu, & Wang, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
260	(Shouli Zhang, Liu, Su, Han, & Li, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
261	(Glawar et al., 2016)	Maintenance Planning	Predictive	Time; Cost	Machine/ Tool; Process;	Vertical	Historical/ Batch	Custom Development	6

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
					Product; Reference				
262	(Jinjiang Wang, Gao, Yuan, Fan, & Zhang, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Probabilistic Methods	4
263	(Chouhal, Mouss, Benaggoune, & Mahdaoui, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Multi-Agent System	5
264	(Harris, Triantafyllopoulos, Stillman, & McLeay, 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
265	(Xiao, Chen, Zhang, & Liu, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
266	(C. Wu, Chen, Jiang, Ning, & Jiang, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
267	(Yoo & Baek, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
268	(Huynh, Grall, & Bérenguer, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
269	(Bousdekis, Magoutas, Apostolou, & Mentzas, 2015)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
270	(Bousdekis, Papageorgiou, Magoutas, Apostolou, & Mentzas, 2017)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	2
271	(Fleischmann, Kohl, & Franke, 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
272	(Cong Wang, Gan, & Zhu, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
273	(Qiao, Wang, Wang, Qiao, & Zhang, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning; Mathematical Optimization	4
274	(Si, Wang, Hu, Chen, & Zhou, 2013)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
275	(Benjamin Y Choo, Adams, Weiss, Marvel, & Beling, 2016)	Condition Analysis	Prescriptive	Time; Cost	Machine/ Tool; Process	Vertical	Historical/ Batch	Mathematical Optimization	2
276	(P. Zhao et al., 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Probabilistic Methods; Clustering	6
277	(Langone, Alzate, Bey-Temsamani, & Suykens, 2014)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
278	(I. Aydin, Karakose, & Akin, 2014)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Fuzzy Logic	5
279	(J. Tian, Azarian, Pecht, Niu, & Li, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
280	(Akhilesh Kumar, Chinnam, & Tseng, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
281	(YS Wang, Ma, Zhu, Liu, & Zhao, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
282	(Dawei Sun, Lee, & Lu, 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Fuzzy Logic	4
283	(C.-J. Kuo, Ting, Chen, Yang, & Chen, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Dimension Reduction	6
284	(Xingqing Wang, Li, Rui, Zhu, & Fei, 2015)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
285	(C. Wu, Chen, & Jiang, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
286	(Soualhi, Medjaher, & Zerhouni, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Regression	4
287	(D. Z. Wu, Jennings, Terpenny, Kumara, & Gao, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Regression	6
288	(JP Patel & Upadhyay, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
289	(Mehta, Werner, & Mears, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Classification	5
290	(Carstensen et al., 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
291	(L. Fu, Wei, Fang, Zhou, & Lou, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
292	(Xia, Xi, Zhou, & Lee, 2013)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Mathematical Optimization	2
293	(Engeler, Treyer, Zogg, Wegener, & Kunz, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
294	(Janssens et al., 2016)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
295	(Chao Wang, Cheng, Nelson, Sawangsri, & Rakowski, 2015)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
296	(Mosallam, Medjaher, & Zerhouni, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
297	(T. Wang, Qiao, Zhang, Yang, & Snoussi, 2018)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Dimension Reduction	6
298	(Jinjiang Wang, Wang, Wang, Huang, & Xue, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
299	(Jianjing Zhang, Peng Wang, Ruqiang Yan, & Robert X Gao, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
300	(Q. Li & S. Y. Liang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
301	(Khelif et al., 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
302	(Fleischmann, Spreng, Kohl, Kißkalt, & Franke, 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
303	(J. A. Carino et al., 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Dimension Reduction	4
304	(J. Luo et al., 2018)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
305	(B. Zhou & Cheng, 2016)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
306	(Unal, Sahin, Onat, Demetgul, & Kucuk, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
307	(H. Peng et al., 2013)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Fuzzy Logic	5
308	(Benkedjouh, Medjaher, Zerhouni, & Rechak, 2015)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
309	(Benkedjouh et al., 2015)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	5
310	(Baraldi, Cannarile, Di Maio, & Zio, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Mathematical Optimization	5
311	(Truong, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
312	(C. Lu, Wang, & Zhou, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
313	(Xiang Li, Zhang, Ding, & Sun, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
314	(R. Kannan, Manohar, & Kumaran, 2019)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
315	(Küfner, Uhlemann, & Ziegler, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
316	(R. Zhao, Yan, Wang, & Mao, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	4
317	(Kanawaday & Sane, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Regression	4
318	(Diaz-Rozo, Bielza, & Larrañaga, 2017)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Clustering	5
319	(Likun Ren, Lv, & Jiang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
320	(Olivotti, Passlick, Dreyer, Lebek, & Breitner, 2018)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Mathematical Optimization	2
321	(Balsamo et al., 2016)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
322	(K. Kannan, Arunachalam, Chawla, & Natarajan, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
323	(Q. Han, Li, Dong, Luo, & Xia, 2017)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
324	(Terrazas, Martínez-Arellano, Benardos, & Ratchev, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
325	(Z. Cheng & Cai, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
326	(L. Ren, Sun, Wang, & Zhang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
327	(Bekar, Skoogh, Cetin, & Siray, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	4
328	(Xiaojun Zhou, Huang, Xi, & Lee, 2015)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Mathematical Optimization	2
329	(Y. Li & Liu, 2018)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Mathematical Optimization	2
330	(Niu & Jiang, 2017)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Mathematical Optimization	2
331	(Shi & Zeng, 2016)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Swarm Intelligence	2
332	(Zhixiang & Jie, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	5
333	(T. Yan, Lei, & Li, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Mathematical Optimization	4
334	(Ellefsen, Bjørlykhaug, Æsøy, Ushakov, & Zhang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning; Evolutional Algorithm	6
335	(L. Hao, Bian, Gebraeel, & Shi, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Regression	4
336	(B. Zhang, Katinas, & Shin, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Fuzzy Logic	4
337	(He Yu, Li, Tian, & Wang, 2018)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression; Swarm Intelligence	6
338	(Xingqiu Li, Jiang, Xiong, & Shao, 2019)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
339	(X. Zhang et al., 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Clustering	5
340	(Schutze & Helwig, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
341	(J. Lee, Kao, & Yang, 2014)	Maintenance Planning	Prescriptive	Time; Cost; Sustainability	Machine/ Tool; Product; ERP	Horizontal	Real-time	Classification; Clustering	2
342	(Neef, Bartels, & Thiede, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
343	(A. Zhang et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
344	(P. Wang, Yan, & Gao, 2017)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
345	(Zhe Zhang, Qin, Jia, & Chen, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
346	(Lenz & Westkaemper, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool; ERP	No Integration	Real-time	Regression	4
347	(Hang, 2016)	Energy Cons. Opt.	Prescriptive	Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Classification; Reinforcement Learning	6
348	(Zuo, Tao, & Nee, 2018)	Energy Cons. Analysis	Descriptive	Sustainability	Machine/ Tool; Process	End-to-End	Real-time	Custom Development	3
349	(Yuxin Wang, Hulstijn, & Tan, 2018)	Security/ Risk Analysis	Descriptive	Time; Cost	Process; ERP	No Integration	Historical/ Batch	Custom Development	3
350	(Ak & Bhinge, 2015)	Energy Cons. Analysis	Predictive	Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Regression; Evolutional Algorithm	6
351	(G. Shao, Brodsky, Shin, & Kim, 2017)	Energy Cons. Opt.	Prescriptive	Sustainability	Machine/ Tool; Process; Product	No Integration	Historical/ Batch	Custom Development	6
352	(S.-J. Shin, Kim, Shao, Brodsky, & Lechevalier, 2017)	Energy Cons. Opt.	Prescriptive	Cost; Sustainability	Machine/ Tool; Process	No Integration	Historical/ Batch	Custom Development	6
353	(Filonenko & Jo, 2018)	Security/ Risk Analysis	Descriptive	Security	Environment	No Integration	Real-time	Classification	3
354	(Ouyang, Sun, Chen, Yue, & Zhang, 2018)	Energy Cons. Analysis	Descriptive	Cost; Sustainability	Machine/ Tool	Vertical; Horizontal	Historical/ Batch	Classification	6
355	(Khalili & Sami, 2015)	Security/ Risk Analysis	Descriptive	Security	Process	No Integration	Real-time	Custom Development	3
356	(Niesen, Houy, Fettke, & Loos, 2016)	Security/ Risk Analysis	Diagnostic	Time; Cost; Conformance	Process; ERP	Vertical	Real-time	Custom Development	3
357	(Y. Zhang, S. Ren, Y. Liu, & S. Si, 2017)	Product Lifecycle Opt.	Prescriptive	Cost; Sustainability	Machine/ Tool; Product; Customer; Human	End-to-End	Real-time	Custom Development	3
358	(C.-Y. Tsai, Chen, & Lo, 2014)	Design Analysis	Predictive	Cost	Product	No Integration	Historical/ Batch	Custom Development	6
359	(Ireland & Liu, 2018)	Design Analysis	Diagnostic	Customer Satisfaction	Product; Customer	End-to-End	Historical/ Batch	Classification	6
360	(Lou, Feng, Zheng, Gao, & Tan, 2018)	Design Analysis	Diagnostic	Customer Satisfaction	Product; Customer	End-to-End	Historical/ Batch	Classification; Fuzzy Logic	6
361	(X. Lai et al., 2018)	Design Analysis	Diagnostic	Customer Satisfaction	Customer	No Integration	Historical/ Batch	Custom Development	6

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
362	(Alexopoulos, Makris, Xanthakis, Sipsas, & Chryssolouris, 2016)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; ERP	Vertical	Real-time	Custom Development	3
363	(K. B. Lee, Cheon, & Kim, 2017)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	No Integration	Historical/ Batch	Deep Learning	5
364	(H. Cai, Guo, & Lu, 2017)	Monitoring	Predictive	Time; Cost; Conformance	Process; Product	No Integration	Real-time	Custom Development	1
365	(Changqing Liu, Li, & Li, 2018)	Production Planning	Descriptive	Time	Process; Product	No Integration	Historical/ Batch	Clustering	3
366	(H. Wang et al., 2017)	Production Planning	Prescriptive	Time; Cost	ERP	No Integration	Historical/ Batch	Mathematical Optimization	2
367	(Hranisavljevic, Niggemann, & Maier, 2016)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
368	(Ci Chen, Xia, Zhou, & Xi, 2015)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process; Product; ERP	No Integration	Real-time	Reinforcement Learning	2
369	(Nouiri, Bekrar, Jemai, Niar, & Ammari, 2018)	Production Planning	Prescriptive	Time; Cost; Flexibility	Machine/ Tool; Process; Product	No Integration	Real-time	Swarm Intelligence; Multi-Agent System	2
370	(Stojanovic, Dinic, Stojanovic, & Stojadinovic, 2016)	Monitoring	Descriptive	Time; Cost; Conformance	Machine/ Tool	No Integration	Real-time	Clustering	4
371	(Cong & Baranowski, 2018)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Classification	3
372	(Caggiano, 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Classification	3
373	(Yi-Jyun Chen, Lee, & Chiu, 2018)	Performanc e Opt.	Diagnostic	Time; Cost	Machine/ Tool; Product	Vertical	Historical/ Batch	Regression	6
374	(Jeff Morgan & O'Donnell, 2018)	Monitoring	Descriptive	Time; Cost; Flexibility	Machine/ Tool; Process	Vertical	Real-time	Classification; Fuzzy Logic	3
375	(P. Wang, Liu, Wang, & Gao, 2018)	Monitoring	Predictive	Time; Cost; Flexibility	Machine/ Tool; Product; Human	No Integration	Real-time	Deep Learning	6
376	(Chuang Wang & Jiang, 2017)	Performanc e Analysis	Predictive	Time; Cost; Flexibility	Process	No Integration	Real-time	Deep Learning	6
377	(Eiskop, Snatkin, Kõrgesaar, & Søren, 2014)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process; ERP	Vertical	Real-time	Custom Development	3
378	(Chao-Chun et al., 2016)	Performanc e Opt.	Diagnostic	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Mathematical Optimization	6
379	(J. P. Liu, Beyca, Rao, Kong, & Bukkapatnam, 2017)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Clustering	3
380	(Denno, Dickerson, & Harding, 2018)	Production Planning	Descriptive	Time; Cost	ERP	No Integration	Historical/ Batch	Evolutional Algorithm	2
381	(Hegenbarth, Bartsch, & Ristow, 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3
382	(Stefan Windmann & Niggemann, 2015)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Historical/ Batch	Probabilistic Methods	3
383	(Ozturk, Bahadir, & Teymourifar, 2018)	Production Planning	Prescriptive	Time; Cost	ERP	No Integration	Historical/ Batch	Evolutional Algorithm	2
384	(Ragab, El-koujok, Amazouz, & Yacout, 2017)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Historical/ Batch	Classification	3
385	(Andonovski, Mušič, & Škrjanc, 2018)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Historical/ Batch	Fuzzy Logic	3
386	(Ragab, El-Koujok, Poulin, Amazouz, & Yacout, 2018)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Historical/ Batch	Classification	3
387	(Arık & Toksarı, 2019)	Production Planning	Prescriptive	Time; Cost	Process; ERP	No Integration	Historical/ Batch	Mathematical Optimization; Fuzzy Logic	2
388	(Peres, Dionisio Rocha, Leitao, & Barata, 2018)	Monitoring	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
389	(Chia-Yu Hsu, 2014)	Performanc e Opt.	Predictive	Time; Cost	Machine/ Tool; Process	No Integration	Historical/ Batch	Regression	6
390	(Westbrink, Chadha, & Schwung, 2018)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Dimension Reduction	3
391	(Tayal & Singh, 2018)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; Product; ERP	No Integration	Historical/ Batch	Swarm Intelligence	2
392	(Kibira, Hatim, Kumara, & Shao, 2015)	Performanc e Opt.	Prescriptive	Time; Cost; Sustainability	Machine/ Tool; Process; Product	No Integration	Historical/ Batch	Mathematical Optimization	2
393	(S. Wang et al., 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool; Product	End-to-End	Real-time	Custom Development	3
394	(Lingitz et al., 2018)	Performanc e Analysis	Predictive	Time; Cost; Flexibility	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
395	(Shuhui, Jie, & Shivani, 2016)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process; Product; ERP	Vertical	Real-time	Reinforcement Learning	2
396	(S. Jain, Shao, & Shin, 2017)	Performanc e Analysis	Diagnostic	Time; Cost		Vertical	Historical/ Batch	Custom Development	6
397	(Marco S. Reis & Rato, 2018)	Monitoring	Predictive	Time; Cost	Process	No Integration	Real-time	Regression	6

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
398	(Ringsquandl et al., 2017)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
399	(Rao, Liu, Roberson, Kong, & Williams, 2015)	Monitoring	Descriptive	Time; Cost; Conformance	Machine/ Tool; Process	No Integration	Real-time	Classification	3
400	(Klöber-Koch, Braunreuther, & Reinhart, 2017)	Production Planning	Predictive	Time; Cost; Security		No Integration	Real-time	Custom Development	6
401	(C. Y. Park, Laskey, Salim, & Lee, 2017)	Monitoring	Predictive	Time; Cost; Conformance	Process; Product	No Integration	Historical/ Batch	Probabilistic Methods	1
402	(Stojanovic & Stojanovic, 2017)	Performance Opt.	Prescriptive	Time; Cost	Machine/ Tool; Process; Human	Vertical	Real-time	Custom Development	2
403	(Hammer, Somers, Karre, & Ramsauer, 2017)	Performance Opt.	Prescriptive	Time	Process	No Integration	Real-time	Mathematical Optimization	2
404	(Subramaniyan, Skoogh, Gopalakrishnan, & Hanna, 2016)	Performance Analysis	Descriptive	Time; Cost; Flexibility	Machine/ Tool	No Integration	Real-time	Custom Development	3
405	(Z. M. Bi et al., 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Custom Development	3
406	(Ray Y Zhong, Li, et al., 2013)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process; ERP	Vertical	Real-time	Custom Development	2
407	(J. Kim & Hwangbo, 2018)	Monitoring	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Clustering	4
408	(Berger, Berlak, & Reinhart, 2016)	Production Planning	Prescriptive	Time; Cost; Flexibility	Machine/ Tool; Process	Vertical	Real-time	Custom Development	2
409	(Mehta, Butkewitsch-Choze, & Seaman, 2018)	Monitoring	Predictive	Time; Cost	Process	No Integration	Real-time	Classification	3
410	(D. Kim et al., 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	3
411	(Q. P. He & Wang, 2017)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Real-time	Custom Development	3
412	(Y. Wu, Wang, Chen, & Yu, 2017)	Performance Opt.	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
413	(R. Kumar, Singh, & Lamba, 2018)	Production Planning	Prescriptive	Time; Cost		No Integration	Historical/ Batch	Dimension Reduction	2
414	(P. Xu, Mei, Ren, & Chen, 2017)	Performance Analysis	Diagnostic	Time; Cost	Process; Product	Vertical	Real-time	Custom Development	3
415	(Diao, Zhao, & Yao, 2015)	Quality Control	Predictive	Time; Cost; Conformance	Process	No Integration	Historical/ Batch	Classification; Dimension Reduction	1
416	(Psarommatis & Kiritsis, 2018)	Quality Opt.	Prescriptive	Time; Cost; Conformance	Machine/ Tool; Process; ERP	Vertical	Real-time	Custom Development	2
417	(S. Du, Liu, & Xi, 2015)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Classification	1
418	(K. Wang, Jiang, & Li, 2016)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Real-time	Regression; Clustering	1
419	(M. Syafrudin et al., 2017)	Quality Control	Predictive	Time; Conformance; Sustainability	Machine/ Tool	No Integration	Real-time	Classification	4
420	(Hirsch, Reimann, Kirn, & Mitschang, 2018)	Quality Control	Diagnostic	Time; Cost; Conformance	Process; Product	No Integration	Historical/ Batch	Custom Development	1
421	(Librantz et al., 2017)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Classification; Dimension Reduction	1
422	(T.-H. Sun, Tien, Tien, & Kuo, 2016)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Classification	1
423	(Nikolai Stein, Meller, & Flath, 2018)	Quality Control	Prescriptive	Time; Cost; Conformance	Process; Product	No Integration	Historical/ Batch	Classification; Regression; Mathematical Optimization	2
424	(Y. Feng & Huang, 2018)	Quality Control	Predictive	Time; Cost; Conformance	Reference	No Integration	Historical/ Batch	Custom Development	1
425	(L. Li, Ota, & Dong, 2018)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Deep Learning	1
426	(Shatnawi & Al-Khassaweneh, 2014)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Classification	1
427	(Rendall et al., 2018)	Quality Control	Predictive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Deep Learning	1
428	(J. Lee, Noh, Kim, & Kang, 2018)	Quality Control	Predictive	Time; Cost; Conformance	Process	Vertical	Real-time	Custom Development	1
429	(Onyeiwu et al., 2017)	Quality Control	Descriptive	Time; Cost; Conformance	Process; Product	No Integration	Real-time	Custom Development	1
430	(Aqlan, Ramakrishnan, & Shamsan, 2017)	Quality Control	Descriptive	Time; Cost; Conformance	Product	Horizontal	Historical/ Batch	Classification	1
431	(Agarwal & Shivpuri, 2014)	Quality Control	Diagnostic	Time; Cost; Conformance	Machine/ Tool; Process; Product	No Integration	Historical/ Batch	Regression	1
432	(J.-K. Park, Kwon, Park, & Kang, 2016)	Quality Control	Descriptive	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Deep Learning	1

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
433	(Xundao Zhou, Zhang, Mao, & Zhou, 2017)	Quality Control	Predictive	Time; Cost; Conformance	Process; Product	No Integration	Historical/ Batch	Custom Development	1
434	(Neto, Gerônimo, Cruz, Aguiar, & Bianchi, 2013)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Product	No Integration	Historical/ Batch	Classification	1
435	(Mashhadi & Behdad, 2017)	Quality Control	Diagnostic	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Clustering	1
436	(Voisin, Laloix, Iung, & Romagne, 2018)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Process; Product	No Integration	Historical/ Batch	Custom Development	1
437	(Shaban, Yacout, Meshreki, Attia, & Balazinski, 2017)	Quality Control	Descriptive	Time; Cost; Conformance	Process; Product	No Integration	Historical/ Batch	Classification	1
438	(Kao, Hsieh, Chen, & Lee, 2017)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Process; Product	No Integration	Historical/ Batch	Classification	1
439	(J.-B. Yu, Yu, Wang, Yuan, & Ji, 2016)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Process; Product	No Integration	Real-time	Regression; Evolutional Algorithm	1
440	(García, Sánchez, Rodríguez-Picón, Méndez-González, & de Jesús Ochoa-Domínguez, 2018)	Quality Control	Predictive	Time; Cost; Conformance	Process; Product	No Integration	Historical/ Batch	Regression	1
441	(Ghadimi, Toosi, & Heavey, 2018)	-	Prescriptive	Time; Cost; Conformance	ERP	Horizontal	Historical/ Batch	Multi-Agent System	-
442	(Laux et al., 2018)	-	Diagnostic	Time; Cost; Flexibility		No Integration	Historical/ Batch	Classification; Dimension Reduction	-
443	(Badurdeen et al., 2014)	-	Diagnostic	Time; Cost; Security		Horizontal	Historical/ Batch	Probabilistic Methods	-
444	(R. Y. Zhong, Lan, Xu, Dai, & Huang, 2016)	-	Descriptive	Time; Cost	Machine/ Tool; Process; Reference	Vertical; Horizontal	Real-time	Custom Development	-
445	(Susto et al., 2014)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Regression	6
446	(Krumeich, Werth, Loos, Schimmelpfennig, & Jacobi, 2014)	Production Planning	Predictive	Time; Cost	Product	Horizontal	Historical/ Batch	Custom Development	6
447	(Susto, Terzi, & Beghi, 2017)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
448	(Tamura, Iizuka, Yamamoto, & Furukawa, 2015)	Production Planning	Prescriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Custom Development	2
449	(L. Zheng et al., 2014)	Performanc e Opt.	Prescriptive	Time; Cost	Process; Product	Vertical	Historical/ Batch	Classification; Regression	2
450	(N. Stein & Flath, 2017)	Monitoring	Predictive	Time; Cost	Machine/ Tool; Product; Reference	Horizontal	Historical/ Batch	Classification	5
451	(Q. Wu, Ding, & Huang, 2018)	Condition Analysis	Predictive	Time; Cost; Conformance	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	6
452	(AlThobiani & Ball, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
453	(Weiß & Vogel-Heuser, 2018)	Quality Control	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
454	(Saldivar, Goh, Li, Yu, & Chen, 2016)	Design Analysis	Predictive	Time; Cost; Customer Satisfaction	Product	Vertical	Historical/ Batch	Clustering	6
455	(Schlegel, Briele, & Schmitt, 2018)	Quality Control	Predictive	Time; Cost; Conformance	Reference	Vertical	Historical/ Batch	Custom Development	1
456	(Khakifirooz, Chien, & Chen, 2018)	Performanc e Opt.	Diagnostic	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Probabilistic Methods	6
457	(Hussain, Mansoor, & Nisar, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
458	(Orman et al., 2015)	Defect Analysis	Descriptive	Time; Cost; Flexibility	Machine/ Tool	No Integration	Real-time	Custom Development	3
459	(G. Zhao et al., 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
460	(W. Ji, Yin, & Wang, 2018)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool	End-to-End	Historical/ Batch	Deep Learning; Evolutional Algorithm	6
461	(Ray Y. Zhong et al., 2015)	Monitoring	Diagnostic	Time; Cost	Process	Vertical	Historical/ Batch	Custom Development	6
462	(Brandenburger et al., 2016)	Quality Control	Descriptive	Time; Cost; Conformance	Process	Vertical	Historical/ Batch	Custom Development	3
463	(J. Yan, Meng, Lu, & Guo, 2017)	Condition Analysis	Predictive	Time; Cost; Flexibility	Machine/ Tool; Product; Customer	Vertical	Real-time	Deep Learning	3
464	(Roy, Li, & Zhu, 2014)	Performanc e Opt.	Predictive	Time; Cost; Flexibility	Process; Product	Vertical; Horizontal	Real-time	Custom Development	3
465	(S. Qu, Chu, Wang, Leckie, & Jian, 2015)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process	Horizontal	Real-time	Reinforcement Learning	2
466	(Åkerman et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical; Horizontal	Historical/ Batch	Classification	6
467	(Batista, Badri, Sabourin, & Thomas, 2013)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
468	(D. Wu, Jennings, Terpenny, & Kumara, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
469	(Y. F. Zhang, Wang, Du, Qian, & Yang, 2018)	Monitoring	Descriptive	Time; Cost; Flexibility		Vertical; Horizontal	Real-time	Custom Development	3
470	(Bai et al., 2018)	Quality Control	Predictive	Time; Cost; Conformance; Customer Satisfaction	Reference	No Integration	Historical/ Batch	Classification	1
471	(Moosavian, Ahmadi, Tabatabaeefar, & Khazaee, 2013)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
472	(Spendla, Kebisek, Tanuska, & Hrcka, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Classification	6
473	(Weigelt, Mayr, Seefried, Heisler, & Franke, 2018)	Quality Control	Predictive	Time; Cost; Conformance; Customer Satisfaction	Process; Reference	Vertical	Real-time	Custom Development	1
474	(Jaramillo, Ottewill, Dudek, Lepiarczyk, & Pawlik, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Custom Development	5
475	(Ragab, Ouali, Yacout, & Osman, 2014)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
476	(Bousdekis & Mentzas, 2017)	Condition Analysis	Predictive	Time; Cost		Vertical	Real-time	Custom Development	3
477	(Weiss et al., 2016)	Quality Control	Predictive	Time; Cost; Conformance; Customer Satisfaction	Machine/ Tool	Horizontal	Real-time	Custom Development	1
478	(Subramaniyan, Skoogh, Salomonsson, Bangalore, Gopalakrishnan, et al., 2018)	Performanc e Analysis	Diagnostic	Time; Cost; Flexibility	Machine/ Tool	Vertical	Real-time	Custom Development	3
479	(Subramaniyan, Skoogh, Salomonsson, Bangalore, & Bokrantz, 2018)	Performanc e Analysis	Predictive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Custom Development	6
480	(Beghi et al., 2016)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Dimension Reduction	5
481	(Fernandes et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
482	(Purarjomandlangr udi, Ghapanchi, & Esmalifalak, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
483	(Denkena, Schmidt, & Krüger, 2014)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	2
484	(Rashid, Amar, Gondal, & Kamruzzaman, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
485	(Y. Ji, Yu, Xu, Yu, & Zhang, 2018)	Production Planning	Predictive	Time; Cost	Product	Vertical	Historical/ Batch	Custom Development	6
486	(Susto & Beghi, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
487	(Uhlmann, Laghmouchi, Geisert, & Hohwieler, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Classification	5
488	(Para, Del Ser, Aguirre, & Nebro, 2018)	Quality Control	Predictive	Cost; Conformance; Customer Satisfaction	Product; Reference	No Integration	Historical/ Batch	Classification	1
489	(Mbuli, Trentesaux, Clarhaut, & Branger, 2017)	Maintenanc e Planning	Prescriptive	Time; Cost	Product	Vertical	Historical/ Batch	Fuzzy Logic	2
490	(C. Zhang, Sun, & Tan, 2015)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
491	(Lin Zhao & Wang, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
492	(Zhe Li, Wang, & Wang, 2019)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
493	(Verstraete, Ferrada, Droguett, Meruane, & Modarres, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
494	(Waschneck et al., 2018a)	Production Planning	Prescriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Reinforcement Learning	2
495	(Q. Li & S. Liang, 2018a)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
496	(Moharana & Sarmah, 2016)	Maintenanc e Planning	Predictive	Time; Cost	Product	No Integration	Historical/ Batch	Custom Development	6
497	(Samui, 2014)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Product; Reference	No Integration	Historical/ Batch	Classification; Regression	1

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
498	(R. He, Dai, Lu, & Mou, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Deep Learning	3
499	(Y. Cheng, M. Chen, et al., 2018)	Security/ Risk Analysis	Descriptive	Flexibility; Security	Human	Vertical; Horizontal	Real-time	Classification	3
500	(Shaban, Yacout, Balazinski, Meshreki, & Attia, 2015)	Quality Control	Diagnostic	Cost; Conformance; Customer Satisfaction	Reference	No Integration	Historical/ Batch	Classification	1
501	(Zhuang, Liu, & Xiong, 2018)	Monitoring	Predictive	Time; Cost; Flexibility	Process	Vertical; Horizontal	Real-time	Custom Development	3
502	(Dolata, Mrzygłód, & Reiner, 2017)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Reference	No Integration	Historical/ Batch	Deep Learning	1
503	(Kang He, Zhao, Jia, & Liu, 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Custom Development	5
504	(Van Horenbeek & Pintelon, 2013)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Custom Development	6
505	(C. Kim, Lee, Kim, Lee, & Lee, 2018)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Historical/ Batch	Custom Development	3
506	(Bousdekis, Papageorgiou, Magoutas, Apostolou, & Mentzas, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
507	(H.-W. Cho, 2015)	Quality Control	Predictive	Time; Cost; Conformance; Customer Satisfaction	Process; Reference	No Integration	Historical/ Batch	Evolutional Algorithm	1
508	(Ketai He, Zhang, Zuo, Alhwiti, & Megahed, 2017)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
509	(Pillai, Punnoose, Vadakkepat, Loh, & Lee, 2018)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Product; Human	No Integration	Historical/ Batch	Fuzzy Logic	1
510	(Anton, Kanoor, Fraunholz, & Schotten, 2018)	Security/ Risk Analysis	Descriptive	Security	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	3
511	(Luangpaiboon, 2015)	Quality Opt.	Prescriptive	Time; Cost; Conformance; Customer Satisfaction	Reference	Horizontal	Historical/ Batch	Custom Development	2
512	(Ai-ming, Jian-min, & Kun, 2016)	Quality Control	Descriptive	Cost; Conformance; Customer Satisfaction	Reference	Horizontal	Historical/ Batch	Probabilistic Methods	1
513	(Tamilselvan & Wang, 2013)	Defect Analysis	Diagnostic	Time; Cost	Process	Vertical	Historical/ Batch	Classification	6
514	(Bakdi, Kouadri, & Bensmail, 2017)	Defect Analysis	Diagnostic	Time; Cost	Process	Horizontal	Historical/ Batch	Dimension Reduction	3
515	(Y. Du & Du, 2018)	Monitoring	Descriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Dimension Reduction	3
516	(Jesus A Carino et al., 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
517	(Haasbroek, Strydom, McCoy, & Auret, 2018)	Monitoring	Descriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Dimension Reduction	3
518	(C. Li, Sánchez, Zurita, Cerrada, & Cabrera, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Deep Learning	5
519	(Mortada, Yacout, & Lakis, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
520	(Krishnakumari, Elayaperumal, Saravanan, & Arvindan, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Fuzzy Logic	5
521	(Gan, Wang, & Zhu, 2018)	Defect Analysis	Descriptive	Time; Cost	Reference	No Integration	Historical/ Batch	Dimension Reduction	5
522	(Cong Wang, Gan, & Zhu, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
523	(H. Lee, 2017)	Monitoring	Descriptive	Time; Cost	Reference	Vertical; Horizontal	Historical/ Batch	Classification	5
524	(Yingfeng Zhang, Ren, Liu, Sakao, & Huisingh, 2017)	Product Lifecycle Opt.	Prescriptive	Time; Cost; Customer Satisfaction	Product	End-to-End	Historical/ Batch	Custom Development	2
525	(Frieß, Kolouch, Friedrich, & Zander, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Clustering	5
526	(R. Ren, Hung, & Tan, 2018)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Reference	No Integration	Historical/ Batch	Deep Learning	1
527	(Schabus & Scholz, 2015)	Performance Opt.	Descriptive	Time; Cost	Process	Vertical	Historical/ Batch	Custom Development	3
528	(B. Y. Choo, Adams, & Beling, 2017)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Reinforcement Learning	2

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
529	(J. Liu, An, Dou, Ji, & Liu, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
530	(J. Tao, Wang, Li, Liu, & Cai, 2016)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Reference	No Integration	Historical/ Batch	Custom Development	1
531	(S. Windmann, Jungbluth, & Niggemann, 2015)	Monitoring	Descriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Probabilistic Methods	3
532	(Roh & Oh, 2016)	Energy Cons. Opt.	Descriptive	Cost; Sustainability	Product	No Integration	Historical/ Batch	Classification; Clustering	3
533	(Saldivar, Goh, Li, Chen, & Yu, 2016)	Design Analysis	Predictive	Time; Cost; Customer Satisfaction	Product; Customer	Vertical	Historical/ Batch	Clustering	6
534	(Jayaram, 2017)	Performanc e Analysis	Predictive	Time; Cost; Flexibility		Vertical; End-to-End	Historical/ Batch	Custom Development	6
535	(Mahdavi, Shirazi, Ghorbani, & Sahebjamnia, 2013)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Process; Reference	Horizontal	Real-time	Multi-Agent System	1
536	(Kai Ding & Jiang, 2016)	Design Analysis	Diagnostic	Time; Cost; Customer Satisfaction	Customer	Vertical	Historical/ Batch	Custom Development	6
537	(Subakti & Jiang, 2018)	Condition Analysis	Descriptive	Time; Cost	Environment	Vertical	Real-time	Deep Learning	3
538	(X. C. Zhu, Qiao, & Cao, 2017)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool; Process; ERP	Vertical	Real-time	Custom Development	2
539	(Sezer, Romero, Guedea, Macchi, & Emmanouilidis, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool; Product	Vertical	Historical/ Batch	Regression	6
540	(Xiong et al., 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
541	(Gouarir, Martínez-Arellano, Terrazas, Benardos, & Ratchev, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Deep Learning	6
542	(Ye, Pan, Chang, & Yu, 2018)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Machine/ Tool	Vertical	Historical/ Batch	Classification	1
543	(XiaoLi Zhang, Wang, & Chen, 2015)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Classification	6
544	(Cong Wang, Gan, & Zhu, 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
545	(Bhinge et al., 2014)	Energy Cons. Analysis	Predictive	Sustainability	Machine/ Tool	Vertical	Historical/ Batch	Regression	6
546	(Z. Li, Wang, & Wang, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	6
547	(Dutta, Mueller, & Liang, 2018)	Energy Cons. Opt.	Predictive	Cost; Sustainability	Environment	Vertical	Historical/ Batch	Custom Development	6
548	(Mourtzis, Milas, & Vlachou, 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
549	(J. Lv et al., 2018)	Energy Cons. Analysis	Predictive	Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
550	(Ayad, Terrissa, & Zerhouni, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical; Horizontal	Historical/ Batch	Custom Development	5
551	(Keizer, Teunter, & Veldman, 2017)	Maintenanc e Planning	Prescriptive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Custom Development	2
552	(Diez-Olivan, Pagan, Khoa, Sanz, & Sierra, 2018)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
553	(Jianjing Zhang, Peng Wang, Ruqiang Yan, & Robert X. Gao, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
554	(Susto, Schirru, Pampuri, McLoone, & Beghi, 2015)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
555	(Candanedo, Nieves, González, Martín, & Briones, 2018)	Condition Analysis	Predictive	Time; Cost	Environment	No Integration	Historical/ Batch	Regression	6
556	(Reina et al., 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
557	(Ying-Jen Chen, Fan, & Chang, 2016; Deuse, Lenze, Klenner, & Friedrich, 2016)	Performanc e Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	-
558	(Ying-Jen Chen et al., 2016)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Machine/ Tool	Vertical	Historical/ Batch	Classification	1
559	(Kamsu-Foguem, Rigal, & Mauget, 2013)	Monitoring	Descriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Custom Development	3

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
560	(Gröger, Stach, Mitschang, & Westkämper, 2016)	Performanc e Opt.	Diagnostic	Time; Cost	Process	Vertical; Horizontal	Historical/ Batch	Custom Development	3
561	(X. Wen & Gong, 2017)	Condition Analysis	Predictive	Time; Cost			Historical/ Batch	Custom Development	6
562	(Dong, Zhang, & Geng, 2014)	Monitoring	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Probabilistic Methods	5
563	(Rivera Torres, Serrano Mercado, Llanes Santiago, & Anido Rifón, 2018)	Maintenanc e Planning	Predictive	Time; Cost	Process	Horizontal	Historical/ Batch	Custom Development	6
564	(Jing Tian, Morillo, Azarian, & Pecht, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
565	(Seera, Lim, & Loo, 2016)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Regression	5
566	(Mashhadi, Cade, & Behdad, 2018)	Quality Control	Predictive	Time; Cost; Conformance; Customer Satisfaction	Product	Vertical; Horizontal	Real-time	Regression	1
567	(Xie et al., 2015)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Product; Reference	Horizontal	Historical/ Batch	Custom Development	1
568	(B. Zhang & Shin, 2018)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	Vertical; Horizontal	Historical/ Batch	Classification	5
569	(J. Morgan & O'Donnell, 2017)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	Vertical; Horizontal	Historical/ Batch	Custom Development	5
570	(Yue Wang & Tseng, 2015)	Design Analysis	Diagnostic	Time; Cost; Customer Satisfaction	Customer	No Integration	Historical/ Batch	Classification	6
571	(L. Wen, Li, Gao, & Zhang, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
572	(H. Liu et al., 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
573	(Guofeng Wang, Zhang, Liu, Xie, & Xu, 2016)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Dimension Reduction	5
574	(R. Kannan, Manohar, & Kumaran, 2018)	Monitoring	Diagnostic	Time; Cost; Flexibility	Machine/ Tool	No Integration	Real-time	Classification	5
575	(Hongyang Yu, Khan, & Garaniya, 2015)	Monitoring	Descriptive	Time; Cost; Flexibility	Process	No Integration	Real-time	Custom Development	3
576	(S. Wang et al., 2017)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
577	(Kisskalt, Fleischmann, Kreitlein, Knott, & Franke, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Probabilistic Methods	5
578	(Gowid, Dixon, & Ghani, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
579	(S.-G. He, He, & Wang, 2013)	Monitoring	Descriptive	Time; Cost	Process	No Integration	Historical/ Batch	Classification	3
580	(Sądel & Śnieżyński, 2017)	Production Planning	Prescriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Reinforcement Learning; Multi-Agent System	2
581	(Duan, Deng, Gong, & Wang, 2018)	Maintenanc e Planning	Prescriptive	Time; Cost	Machine/ Tool	Horizontal	Historical/ Batch	Evolutional Algorithm	2
582	(Shuhui Qu, Wang, Govil, & Leckie, 2016)	Production Planning	Prescriptive	Time; Cost	Product; Human	Vertical; Horizontal	Real-time	Reinforcement Learning	2
583	(Kan, Yang, & Kumara, 2018)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical; Horizontal	Historical/ Batch	Custom Development	5
584	(S. Tangjitsitcharoen, Thesniyom, & Ratanakuakangwa n, 2017)	Quality Control	Predictive	Time; Cost; Conformance; Customer Satisfaction	Machine/ Tool; Product	No Integration	Historical/ Batch	Regression	1
585	(S.-J. Shin, Woo, & Rachuri, 2014)	Energy Cons. Analysis	Predictive	Sustainability	Machine/ Tool	Vertical	Historical/ Batch	Classification	6
586	(Oyekanlu, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	Vertical; Horizontal	Real-time	Custom Development	3
587	(Kajmakovic et al., 2018)	Security/ Risk Analysis	Predictive	Security	Machine/ Tool; Environment; Human	Horizontal	Historical/ Batch	Custom Development	3
588	(Akhavei & Bleicher, 2016)	Production Planning	Predictive	Time; Cost	Process	No Integration	Historical/ Batch	Regression	6
589	(Kireev et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	6
590	(R. Jain, Singh, & Mishra, 2013)	Quality Control	Prescriptive		Process; Environment; Human	Horizontal	Historical/ Batch	Fuzzy Logic	3
591	(Alexander Brodsky, Shao, & Riddick, 2016)	Monitoring	Descriptive	Time; Cost; Sustainability	Process	No Integration	Historical/ Batch	Custom Development	3
592	(Oh et al., 2013)	Quality Control	Predictive	Time; Cost; Conformance; Customer Satisfaction	Reference	Horizontal	Real-time	Classification	1

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
593	(Ragab, Yacout, Ouali, & Osman, 2016)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
594	(D. Kim, Han, Lin, Kang, & Lee, 2018)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
595	(Jinzhi Wang, Qu, Wang, Leckie, & Xu, 2017)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process	Horizontal	Historical/ Batch	Reinforcement Learning	2
596	(Gajjar, Kulahci, & Palazoglu, 2018)	Monitoring	Descriptive	Time; Cost	Process	Horizontal	Real-time	Custom Development	3
597	(M. Canizo, Onieva, Conde, Charramendieta, & Trujillo, 2017)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Classification	4
598	(Židek, Hosovsky, Piteľ, & Bednár, 2019)	Performanc e Opt.	Descriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Deep Learning	3
599	(Duong et al., 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
600	(Ahmad, Khan, Islam, & Kim, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
601	(X. Chen, Shen, He, Sun, & Liu, 2013)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
602	(Xiang Li, Ding, & Sun, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
603	(Al Sunny, Liu, & Shahriar, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	6
604	(Q. Zhou, Yan, Liu, Xin, & Chen, 2018)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Custom Development	6
605	(Shuai Zhang, Zhang, & Zhu, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Probabilistic Methods	6
606	(Ray Y Zhong, Dai, Qu, Hu, & Huang, 2013)	Production Planning	Prescriptive	Time; Cost; Customer Satisfaction	Process	Vertical; Horizontal	Real-time	Multi-Agent System	2
607	(Hinchi & Tkiouat, 2018)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	End-to-End	Historical/ Batch	Deep Learning	6
608	(Prosvirin, Islam, Kim, & Kim, 2018)	Defect Analysis	Diagnostic	Time; Cost	Product	No Integration	Historical/ Batch	Classification	5
609	(Gawand, Bhattacharjee, & Roy, 2017)	Security/ Risk Analysis	Descriptive	Security	Machine/ Tool; Environment	Vertical	Historical/ Batch	Custom Development	3
610	(Lavrova, Poltavtseva, & Shtyrkina, 2018)	Security/ Risk Analysis	Descriptive	Security	Process	Vertical	Historical/ Batch	Custom Development	3
611	(M. Zheng & Wu, 2017)	Maintenanc e Planning	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Custom Development	3
612	(Germen, Başaran, & Fidan, 2014)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Dimension Reduction	5
613	(Shimada & Sakajo, 2016)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
614	(Q. Peter He & Jin Wang, 2018)	Monitoring	Descriptive	Time; Cost	Process	Vertical	Real-time	Custom Development	3
615	(Q Peter He & Jin Wang, 2018)	Monitoring	Descriptive	Time; Cost	Process	Vertical	Real-time	Custom Development	3
616	(Mayer, Mayer, & Abdo, 2017)	Monitoring	Descriptive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Classification; Clustering	5
617	(Gururajapathy, Mokhlis, Illias, & Awalin, 2017)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
618	(Ray & Mishra, 2016)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
619	(H.-J. Shin, Cho, & Oh, 2018)	Defect Analysis	Predictive	Time; Cost	Process	Horizontal	Historical/ Batch	Classification	2
620	(Palacios, González-Rodríguez, Vela, & Puente, 2015)	Production Planning	Prescriptive	Time; Cost	Process	No Integration	Historical/ Batch	Swarm Intelligence	2
621	(C.-F. Chien, S.-C. Hsu, & Y.-J. Chen, 2013)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Machine/ Tool	Vertical	Historical/ Batch	Classification	1
622	(D. Song & Yang, 2018)	Monitoring	Predictive	Time; Cost	Environment	No Integration	Historical/ Batch	Regression	6
623	(Morariu & Borangiu, 2018)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process	Vertical	Real-time	Deep Learning	2
624	(G. F. Wang, Xie, & Zhang, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Evolutional Algorithm	5
625	(Tao Li, Zhang, Luo, & Wu, 2017)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
626	(Karandikar, McLeay, Turner, & Schmitz, 2015)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	5
627	(A. Brodsky, Krishnamoorthy, Menascé, Shao, & Rachuri, 2014)	Performanc e Opt.	Prescriptive	Time; Cost	Process	Vertical; Horizontal	Historical/ Batch	Custom Development	3
628	(Oliff & Liu, 2017)	Quality Control	Descriptive	Time; Cost; Conformance;	Process; Reference	Vertical	Historical/ Batch	Classification	1

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
629	(Flath & Stein, 2018)	Quality Control	Predictive	Customer Satisfaction Time; Cost; Conformance; Customer Satisfaction	Process	Vertical	Historical/ Batch	Custom Development	1
630	(Sanchez, Conde, Arriandiaga, Wang, & Plaza, 2018)	Monitoring	Predictive	Time; Cost	Machine/ Tool	Vertical	Historical/ Batch	Deep Learning	6
631	(Vazan, Janikova, Tanuska, Kebisek, & Cervenanska, 2017)	Monitoring	Predictive	Time; Cost	Process	Vertical; Horizontal	Historical/ Batch	Custom Development	6
632	(R. Jain, Singh, Yadav, & Mishra, 2014)	Product Lifecycle Opt.	Prescriptive	Time; Cost	ERP; Human	Horizontal	Historical/ Batch	Classification	2
633	(Baban, Baban, & Suteu, 2016)	Condition Analysis	Predictive	Time; Cost; Flexibility	Machine/ Tool	No Integration	Historical/ Batch	Fuzzy Logic	6

Table A.3 Coded Publications from Second Literature Survey with Clusters (*n*=232)

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
634	(A. Zhang et al., 2019)	Defect Analysis	Predictive	Time; Cost	Product	No Integration	Historical/ Batch	Deep Learning	6
635	(Abidi, Alkhalefah, Mohammed, Umer, & Qudeiri, 2020)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process	No Integration	Historical/ Batch	Classification; Regression; Deep Learning; Mathematical Optimization; Fuzzy Logic	2
636	(Alavian, Eun, Meerkov, & Zhang, 2020)	Performanc e Opt.	Prescriptive	Time; Cost; Flexibility	Machine/ Tool; Process; Product	Vertical	Real-time	Probabilistic Methods; Mathematical Optimization; Custom Development	2
637	(Alexopoulos, Nikolakis, & Chryssolouris, 2020)	Design Analysis	Descriptive	Time; Cost; Conformance	Reference; ERP	End-to-End	Historical/ Batch	Regression; Deep Learning	6
638	(Alfeo, Cimino, Manco, Ritacco, & Vaglini, 2020)	Design Analysis	Diagnostic	Conformance	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	1
639	(Ansari, Glawar, & Nemeth, 2019)	Maintenanc e Planning	Prescriptive	Time	Machine/ Tool; ERP	Vertical	Historical/ Batch	Custom Development	2
640	(Arachchige et al., 2020)	Security/ Risk Analysis	Descriptive	Security; Customer Satisfaction	Machine/ Tool; Customer	Vertical; Horizontal	Historical/ Batch	Deep Learning	3
641	(Arellano-Espitia, Delgado-Prieto, Martinez-Viol, Saucedo-Dorantes, & Osornio-Rios, 2020)	Defect Analysis	Diagnostic	Sustainability	Machine/ Tool	No Integration	Real-time	Deep Learning	4
642	(Arpaia, Moccaldi, Prevete, Sannino, & Tedesco, 2020)	Security/ Risk Analysis	Predictive	Cost; Security	Human	No Integration	Real-time	Classification	3
643	(Ashish Kumar, Dimitrakopoulos, & Maulen, 2020)	Production Planning	Prescriptive	Time; Cost; Flexibility	ERP; Environment	End-to-End	Real-time	Classification; Probabilistic Methods; Deep Learning; Reinforcement Learning; Mathematical Optimization; Custom Development	2
644	(Aydemir & Paynabar, 2019)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression; Deep Learning	6
645	(B. Chen et al., 2019)	Performanc e Opt.	Descriptive	Time; Cost; Flexibility	Machine/ Tool	No Integration	Real-time	Deep Learning; Reinforcement Learning	3
646	(B. Yang, Cao, Li, Zhang, & Qian, 2019)	Condition Analysis	Prescriptive	Time; Conformance	Process	No Integration	Historical/ Batch	Custom Development	2
647	(B.-A. Han & Yang, 2020)	Production Planning	Prescriptive	Time; Cost; Flexibility	ERP	No Integration	Historical/ Batch	Deep Learning; Reinforcement Learning	2
648	(Barde, Yacout, & Shin, 2019)	Maintenanc e Planning	Prescriptive	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Probabilistic Methods; Reinforcement Learning; Mathematical Optimization	2
649	(Bowler, Bakalis, & Watson, 2020)	Monitoring	Predictive	Cost	Reference; Environment	No Integration	Real-time	Classification; Deep Learning	6

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
650	(C. Xu & Zhu, 2020)	Quality Control	Descriptive	Conformance	Product	Horizontal	Real-time	Classification	1
651	(C.-C. Lin, Deng, Chih, & Chiu, 2019)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning; Reinforcement Learning	2
652	(C.-C. Lin, Deng, Kuo, & Chen, 2019)	Condition Analysis	Predictive	Time; Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Classification; Regression	6
653	(C.-F. Lai, Chien, Yang, & Qiang, 2019)	Monitoring	Prescriptive	Cost; Conformance	Machine/ Tool	No Integration	Historical/ Batch	Classification	1
654	(C.-M. Kuo, Chen, Tseng, & Kao, 2020)	Design Analysis	Predictive	Customer Satisfaction	Customer; Human	No Integration	Historical/ Batch	Custom Development	6
655	(C.-Y. Wang, Chen, & Chien, 2020)	Performanc e Opt.	Predictive	Cost	Product	No Integration	Historical/ Batch	Clustering; Mathematical Optimization	6
656	(Cakir, Guvenc, & Mistikoglu, 2020)	Condition Analysis	Predictive	Cost	Machine/ Tool; Environment	No Integration	Real-time	Classification	4
657	(Carvajal Soto, Tavakolizadeh, & Gyulai, 2019)	Quality Control	Predictive	Time; Conformance; Flexibility	Product	No Integration	Real-time	Classification; Deep Learning	1
658	(Chang Liu, Li, Tang, Lin, & Liu, 2019)	Production Planning	Prescriptive	Time; Cost	Process; Customer	Horizontal	Real-time	Reinforcement Learning; Mathematical Optimization	2
659	(Chang Liu, Tang, & Liu, 2019)	Quality Opt.	Prescriptive	Conformance; Security	Process	Horizontal	Historical/ Batch	Regression	3
660	(Chang Liu, Tang, Liu, & Tang, 2018)	Quality Control	Prescriptive	Time; Cost; Conformance	Process	No Integration	Real-time	Regression; Dimension Reduction	2
661	(Che, Liu, Che, & Lang, 2020)	Production Planning	Prescriptive	Time; Cost	Process	No Integration	Historical/ Batch	Mathematical Optimization	2
662	(Cheol Young Park, Kim, Kim, & Lee, 2020)	Quality Opt.	Predictive	Cost; Conformance	Machine/ Tool	No Integration	Real-time	Regression; Clustering	4
663	(Chong Chen, Liu, Kumar, Qin, & Ren, 2019)	Energy Cons. Analysis	Predictive	Cost; Sustainability	Reference	No Integration	Historical/ Batch	Deep Learning	6
664	(Chouliaras & Sotiriadis, 2019)	Monitoring	Predictive	Cost; Conformance	Process	Horizontal	Real-time	Deep Learning	6
665	(Chu, Xie, Wu, Guo, & Yau, 2020)	Quality Opt.	Descriptive	Cost; Conformance; Customer Satisfaction	Reference	No Integration	Historical/ Batch	Regression; Evolutional Algorithm; Multi-Agent System	1
666	(Cui, Ren, Wang, & Zhang, 2019)	Condition Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Real-time	Regression; Deep Learning; Custom Development	4
667	(D. B. Kim, 2019)	Performanc e Opt.	Prescriptive	Conformance; Flexibility	Machine/ Tool; Process; Product	Vertical	Historical/ Batch	Custom Development	2
668	(D. Wu et al., 2019)	Monitoring	Descriptive	Time	Machine/ Tool	No Integration	Real-time	Classification; Probabilistic Methods; Deep Learning	3
669	(Dai, Wang, Huang, Shi, & Zhu, 2020)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Dimension Reduction; Deep Learning	5
670	(Dan et al., 2020)	Quality Opt.	Predictive	Time; Cost; Conformance	Machine/ Tool	No Integration	Historical/ Batch	Dimension Reduction; Deep Learning	1
671	(de Farias, de Almeida, Delijaicov, Seriacopi, & Bordinassi, 2020)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
672	(de Sa, Carmo, & Machado, 2017)	Security/ Risk Analysis	Diagnostic	Security	ERP	No Integration	Real-time	Mathematical Optimization; Swarm Intelligence	3
673	(Demertzis, Iliadis, Tziritas, & Kikiras, 2020)	Security/ Risk Analysis	Predictive	Security	Process	Vertical	Real-time	Classification; Deep Learning; Custom Development	3
674	(Deng et al., 2020)	Monitoring	Prescriptive	Time; Cost	Process	No Integration	Historical/ Batch	Classification; Deep Learning	2
675	(Denkena, Bergmann, & Witt, 2019)	Performanc e Opt.	Predictive	Conformance; Flexibility	Machine/ Tool; Process	No Integration	Historical/ Batch	Classification; Dimension Reduction; Deep Learning	1
676	(Dimitriou et al., 2019)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool	No Integration	Historical/ Batch	Classification; Deep Learning	1
677	(Doltsinis, Krestenitis, & Doulgeri, 2019)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool	No Integration	Real-time	Classification	4
678	(Dong Sun et al., 2019)	Production Planning	Diagnostic	Time; Cost	ERP	End-to-End	Historical/ Batch	Clustering	6
679	(Elgendi, Hossain, Jamalipour, & Munasinghe, 2019)	Security/ Risk Analysis	Prescriptive	Cost; Security	Process	Vertical	Historical/ Batch	Classification	3
680	(Elsheikh, Yacout, Ouali, & Shaban, 2020)	Condition Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Real-time	Classification; Regression; Custom Development	4

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
681	(Epureanu, Li, Nassehi, & Koren, 2020)	Maintenance Planning	Prescriptive	Time; Cost; Flexibility	Machine/ Tool; Product; ERP	Vertical	Historical/ Batch	Reinforcement Learning	2
682	(Essien & Giannetti, 2020)	Production Planning	Predictive	Time; Cost	Machine/ Tool	End-to-End	Historical/ Batch	Dimension Reduction; Deep Learning	6
683	(Ezeme, Mahmoud, & Azim, 2019)	Monitoring	Diagnostic	Time; Security	Machine/ Tool; Process	No Integration	Historical/ Batch	Deep Learning	5
684	(Faraci, Raciti, Rizzo, & Schembra, 2020)	Energy Cons. Opt.	Prescriptive	Time; Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Reinforcement Learning	6
685	(Farivar, Haghighi, Jolfaei, & Alazab, 2019)	Security/ Risk Analysis	Predictive	Security	Process	No Integration	Historical/ Batch	Deep Learning	3
686	(Foresti, Rossi, Magnani, Bianco, & Delmonte, 2020)	Maintenance Planning	Predictive	Time; Cost; Conformance; Sustainability	ERP; Human	Vertical	Real-time	Custom Development	3
687	(Frumosu et al., 2020)	Quality Control	Predictive	Time; Cost; Conformance	Process; Reference	No Integration	Historical/ Batch	Classification; Evolutional Algorithm	1
688	(G. G. Rodríguez, Gonzalez-Cava, & Pérez, 2019)	Production Planning	Predictive	Time; Cost	Process; ERP; Environment	End-to-End	Real-time	Fuzzy Logic	6
689	(Gang Wang, Nixon, & Boudreaux, 2019)	Condition Analysis	Predictive	Time	Machine/ Tool	End-to-End	Real-time	Regression	4
690	(Gao, Zhang, Chen, Dong, & Vucetic, 2018)	Energy Cons. Opt.	Predictive	Cost	Machine/ Tool	Horizontal	Real-time	Mathematical Optimization	6
691	(Genge, Haller, & Enăchescu, 2019)	Security/ Risk Analysis	Predictive	Security	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	3
692	(Ghahramani, Qiao, Zhou, Hagan, & Sweeney, 2020)	Performance Opt.	Predictive	Time; Cost	Process	Vertical	Historical/ Batch	Dimension Reduction; Deep Learning	6
693	(Gou et al., 2019)	Condition Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Real-time	Mathematical Optimization	4
694	(Grzenda & Bustillo, 2019)	Quality Opt.	Predictive	Time; Cost; Conformance	Machine/ Tool	No Integration	Real-time	Classification; Regression; Custom Development	4
695	(H. Hu, Jia, He, Fu, & Liu, 2020)	Production Planning	Prescriptive	Time; Flexibility	Machine/ Tool; Process	Vertical	Real-time	Reinforcement Learning	2
696	(H. Huang et al., 2019)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Deep Learning	4
697	(H. Wang, Li, Song, Cui, & Wang, 2019)	Defect Analysis	Predictive	Cost	Machine/ Tool; Product	No Integration	Historical/ Batch	Clustering; Deep Learning	6
698	(H. Wang, Ren, Song, & Cui, 2019)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification	6
699	(H. Xu, Liu, Yu, Griffith, & Golmie, 2020)	Performance Opt.	Prescriptive	Flexibility	Reference; Environment	Vertical	Historical/ Batch	Reinforcement Learning	2
700	(H. Yang, Alphones, Zhong, Chen, & Xie, 2019)	Energy Cons. Opt.	Prescriptive	Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning; Reinforcement Learning	6
701	(H. Yao et al., 2019)	Security/ Risk Analysis	Descriptive	Security	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	3
702	(H.-K. Wang & Chien, 2020)	Quality Opt.	Prescriptive	Cost; Conformance	Process; Reference	No Integration	Historical/ Batch	Evolutional Algorithm	1
703	(Halawa et al., 2020)	Security/ Risk Analysis	Descriptive	Security	Process	End-to-End	Real-time	Custom Development	3
704	(Hassan, Gumaei, Huda, & Almogren, 2020)	Security/ Risk Analysis	Descriptive	Security; Customer Satisfaction	Reference	End-to-End	Historical/ Batch	Classification; Regression	3
705	(I. Rodríguez et al., 2020)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process	No Integration	Historical/ Batch	Classification	2
706	(Iannino et al., 2020)	Performance Opt.	Predictive	Time; Cost	Process	Horizontal	Real-time	Multi-Agent System	3
707	(Ismail, Idris, Ayub, & Yee, 2019)	Quality Control	Predictive	Time; Conformance	Product; Reference	No Integration	Historical/ Batch	Classification	1
708	(J. Chen, Zhang, & Wu, 2020)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Reference	No Integration	Real-time	Classification; Deep Learning	4
709	(J. Feng, Li, Xu, & Zhong, 2018)	Quality Control	Descriptive	Time; Conformance	Process	No Integration	Historical/ Batch	Classification	1
710	(J. Jiao, Lin, Zhao, & Liang, 2020)	Defect Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Real-time	Classification; Deep Learning; Reinforcement Learning; Multi-Agent System; Custom Development	4
711	(J. Li, Xu, Gao, Wang, & Shao, 2020)	Quality Control	Predictive	Conformance	Machine/ Tool	No Integration	Real-time	Classification; Dimension Reduction; Deep Learning; Reinforcement Learning; Multi-Agent System; Custom Development	4

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
712	(J. Liu et al., 2020)	Security/ Risk Analysis	Descriptive	Security	Machine/ Tool	Vertical; Horizontal	Historical/ Batch	Probabilistic Methods	3
713	(J. Luo, Chen, Yu, & Tang, 2020)	Energy Cons. Opt.	Prescriptive	Time; Cost	Process	Vertical	Historical/ Batch	Deep Learning; Reinforcement Learning	2
714	(Jha, Babiceanu, & Seker, 2019)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process; ERP	End-to-End	Real-time	Mathematical Optimization	2
715	(Jing Yang, Li, Wang, & Yang, 2019)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool	No Integration	Real-time	Deep Learning	4
716	(Jinjiang Wang, Yan, Li, Gao, & Zhao, 2019)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
717	(Jinjiang Wang, Ye, Gao, Li, & Zhang, 2019)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Mathematical Optimization; Custom Development	3
718	(Jomthanachai, Rattanamanee, Sinthavalai, & Wong, 2020)	Quality Opt.	Diagnostic	Time; Cost; Conformance	Product	No Integration	Historical/ Batch	Evolutional Algorithm	1
719	(Jonghyuk Kim & Hwangbo, 2019)	Monitoring	Predictive	Time; Sustainability	Process	No Integration	Real-time	Custom Development	3
720	(K. H. Sun et al., 2020)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
721	(K. T. Park et al., 2020)	Energy Cons. Opt.	Predictive	Sustainability	Machine/ Tool; Process; ERP; Environment	End-to-End	Real-time	Classification; Regression; Deep Learning	6
722	(K. Wang et al., 2020)	Energy Cons. Opt.	Prescriptive	Cost	Process	Vertical	Real-time	Reinforcement Learning	2
723	(K. Zhu & Lin, 2019)	Condition Analysis	Predictive	Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Dimension Reduction	6
724	(K. Zhu, Li, & Zhang, 2019)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Deep Learning	4
725	(Kabugo, Jämsä-Jounela, Schiemann, & Binder, 2020)	Monitoring	Predictive	Time; Cost	Product	End-to-End	Real-time	Deep Learning	6
726	(Kai Ding, Zhang, Chan, Chan, & Wang, 2019)	Production Planning	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Probabilistic Methods	2
727	(Kazi, Eljack, & Mahdi, 2020)	Quality Control	Predictive	Conformance	Product; Reference	No Integration	Historical/ Batch	Deep Learning	1
728	(Ke, Chen, Chen, Wang, & Zhang, 2020)	Production Planning	Prescriptive	Time	ERP	No Integration	Historical/ Batch	Swarm Intelligence	2
729	(Khoda, Imam, Kamruzzaman, Gondal, & Rahman, 2019)	Security/ Risk Analysis	Predictive	Security	Reference	No Integration	Historical/ Batch	Classification	3
730	(Kiangala & Wang, 2020)	Condition Analysis	Predictive	Cost; Security	Machine/ Tool; Environment	No Integration	Historical/ Batch	Classification; Dimension Reduction; Deep Learning	6
731	(König & Helmi, 2020)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	5
732	(Konstantakopoulos et al., 2019)	Energy Cons. Opt.	Predictive	Sustainability; Customer Satisfaction	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	6
733	(Krishnamurthy, Karri, & Khorrami, 2019)	Monitoring	Diagnostic	Time; Cost; Security	Machine/ Tool	Vertical	Real-time	Classification	3
734	(L. Hu, Miao, Wu, Hassan, & Humar, 2019)	Performance Opt.	Prescriptive	Time; Flexibility; Customer Satisfaction	Machine/ Tool; Product; Customer	Horizontal	Real-time	Deep Learning; Custom Development	2
735	(L. Jin, Zhang, Wen, & Christopher, 2020)	Production Planning	Prescriptive	Time; Cost	Process	Vertical	Historical/ Batch	Evolutional Algorithm	2
736	(L. Song et al., 2019)	Quality Opt.	Predictive	Cost; Conformance	Machine/ Tool	No Integration	Historical/ Batch	Classification	1
737	(Latif, Zou, Idrees, & Ahmad, 2020)	Security/ Risk Analysis	Predictive	Security	Machine/ Tool	No Integration	Historical/ Batch	Classification; Deep Learning	3
738	(Lei Ren, Meng, Wang, Lu, & Yang, 2020)	Quality Control	-	Cost; Conformance	Process	No Integration	Historical/ Batch	Dimension Reduction	1
739	(Lenz, MacDonald, Harik, & Wuest, 2020)	Product Lifecycle Opt.	Descriptive	Time; Cost; Conformance	Machine/ Tool; Product	Horizontal	Real-time	Custom Development	3
740	(Liao et al., 2019)	Performance Opt.	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Mathematical Optimization	2
741	(Linlin Li, Wang, Wang, & Tang, 2019)	Energy Cons. Opt.	Prescriptive	Cost; Sustainability	Process	Vertical	Historical/ Batch	Mathematical Optimization; Evolutional Algorithm	2
742	(Lithoxoidou et al., 2020)	Condition Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Real-time	Classification; Clustering	4
743	(Lolli et al., 2019)	Production Planning	Diagnostic	Time; Cost; Flexibility	Reference	Horizontal	Historical/ Batch	Classification	2

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
744	(Long Wen, Gao, & Li, 2017)	Quality Control	Predictive	Conformance	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	1
745	(Longo, Nicoletti, & Padovano, 2019)	Security/ Risk Analysis	Descriptive	Security	Process; Human	No Integration	Historical/ Batch	Custom Development	3
746	(M. Chen, 2019)	Performanc e Opt.	Predictive	Cost; Customer Satisfaction	Customer	No Integration	Historical/ Batch	Classification	6
747	(M. T. Nguyen, Truong, Tran, & Chien, 2020)	Monitoring	Descriptive	Time; Cost	Process; Environment	Vertical	Real-time	Dimension Reduction	3
748	(M. Wu & Moon, 2019)	Security/ Risk Analysis	Predictive	Cost; Security	Machine/ Tool; Process; ERP	End-to-End	Historical/ Batch	Classification	3
749	(M. Wu, Song, & Moon, 2019)	Security/ Risk Analysis	Descriptive	Security	Reference	No Integration	Real-time	Classification	3
750	(M. Zhang et al., 2019)	Security/ Risk Analysis	Diagnostic	Security	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	3
751	(Maggipinto, Beghi, McLoone, & Susto, 2019)	Design Analysis	Predictive	Time; Cost	Reference; Environment	No Integration	Historical/ Batch	Deep Learning	6
752	(Malaca, Rocha, Gomes, Silva, & Veiga, 2019)	Quality Control	Predictive	Time; Cost; Conformance; Flexibility	Machine/ Tool; Reference; Environment; Human	No Integration	Real-time	Classification; Dimension Reduction; Deep Learning	4
753	(Martinek & Krammer, 2019)	Performanc e Opt.	Predictive	Time; Cost; Conformance	Machine/ Tool; Process	No Integration	Historical/ Batch	Classification; Deep Learning; Fuzzy Logic	1
754	(Martinez, Al-Hussein, & Ahmad, 2020)	Quality Control	Diagnostic	Cost	Product	No Integration	Real-time	Classification	1
755	(Martínez-Arellano, Terrazas, & Ratchev, 2019)	Condition Analysis	Predictive	Cost; Conformance	Machine/ Tool	No Integration	Historical/ Batch	Classification; Deep Learning	1
756	(Mi et al., 2020)	Maintenanc e Planning	Prescriptive	Time; Cost; Security; Sustainability	Machine/ Tool	No Integration	Real-time	Mathematical Optimization	2
757	(Miao, Hsieh, Segura, & Wang, 2019)	Performanc e Opt.	Predictive	Cost	Product; Environment	No Integration	Historical/ Batch	Regression	6
758	(Mikel Canizo, Conde, et al., 2019)	Monitoring	Predictive	Cost; Conformance	Machine/ Tool	Horizontal	Historical/ Batch	Deep Learning	6
759	(Mikel Canizo, Triguero, Conde, & Onieva, 2019)	Monitoring	Predictive	Time	Process	No Integration	Real-time	Deep Learning	3
760	(Min, Lu, Liu, Su, & Wang, 2019)	Performanc e Opt.	Prescriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification	4
761	(Mishra et al., 2020)	Monitoring	Predictive	Conformance	Machine/ Tool; Process	Vertical	Real-time	Custom Development	3
762	(Moens et al., 2020)	Condition Analysis	Predictive	Time	Machine/ Tool	Horizontal	Historical/ Batch	Classification; Deep Learning	6
763	(Moreira, Li, Lu, & Fitzpatrick, 2019)	Quality Control	Predictive	Conformance	Machine/ Tool; Product	No Integration	Real-time	Custom Development	1
764	(Mörth, Emmanouilidis, Hafner, & Schadler, 2020)	Performanc e Analysis	Descriptive	Cost	Process	End-to-End	Real-time	Custom Development	3
765	(Muhammad Syafrudin, Fitriyani, Alfian, & Rhee, 2019)	Monitoring	Predictive	Time; Cost; Customer Satisfaction	Process; Environment	No Integration	Real-time	Classification; Custom Development	3
766	(Muhammad, Hussain, Del Ser, Palade, & De Albuquerque, 2019)	Monitoring	Predictive	Cost	Environment	Vertical	Historical/ Batch	Deep Learning	6
767	(Mumtaz et al., 2019)	Production Planning	Prescriptive	Time; Cost	Process	Horizontal	Historical/ Batch	Mathematical Optimization; Swarm Intelligence	2
768	(N. Li et al., 2020)	Condition Analysis	Predictive	Time; Conformance	Machine/ Tool	No Integration	Real-time	Classification; Regression	4
769	(Neupane & Seok, 2020)	Defect Analysis	Descriptive	Time; Cost; Security	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
770	(Ortego et al., 2020)	Performanc e Analysis	Predictive	Time; Cost	Process	No Integration	Historical/ Batch	Classification; Deep Learning; Evolutional Algorithm	6
771	(P. Fang, Yang, Zheng, Zhong, & Jiang, 2020)	Monitoring	Descriptive	Conformance	Process; ERP	Horizontal	Historical/ Batch	Probabilistic Methods	3
772	(P. Li, Cheng, Jiang, & Katchasuwanmane e, 2020)	Monitoring	Descriptive	Cost	Machine/ Tool	No Integration	Real-time	Dimension Reduction; Custom Development	3
773	(P. Liu, Zhang, Wu, & Fu, 2020)	Condition Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Real-time	Dimension Reduction	4
774	(P. Peng, Zhang, Liu, Wang, & Zhang, 2019)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool; Process	No Integration	Real-time	Dimension Reduction; Evolutional Algorithm	4

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
775	(P. Wang & Gao, 2020)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
776	(Papananias, McLeay, Mahfouf, & Kadirkamanathan, 2019)	Quality Control	Predictive	Cost; Conformance	Process	Horizontal	Real-time	Regression	1
777	(Papananias, McLeay, Obajemu, Mahfouf, & Kadirkamanathan, 2020)	Quality Control	Predictive	Time; Conformance	Product	No Integration	Historical/ Batch	Regression; Probabilistic Methods	1
778	(Para, Del Ser, Nebro, Zurutuza, & Herrera, 2019)	Monitoring	Descriptive	Cost	Process; Human	Vertical	Historical/ Batch	Classification	3
779	(Penumuru, Muthuswamy, & Karumbu, 2019)	Quality Control	Predictive	Conformance	Reference	No Integration	Historical/ Batch	Classification; Regression	1
780	(Peres, Barata, Leitao, & Garcia, 2019)	Quality Control	Predictive	Conformance	Product	No Integration	Historical/ Batch	Classification	1
781	(Petrović, Miljković, & Jokić, 2019)	Production Planning	Prescriptive	Time; Cost; Flexibility; Sustainability	Process	No Integration	Historical/ Batch	Mathematical Optimization; Swarm Intelligence	2
782	(Pierezan, Maidl, Yamao, dos Santos Coelho, & Mariani, 2019)	Energy Cons. Opt.	Descriptive	Conformance; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Mathematical Optimization	1
783	(Pittino, Puggl, Moldaschl, & Hirschl, 2020)	Condition Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Real-time	Deep Learning	5
784	(Plehiers et al., 2019)	Performanc e Opt.	Predictive	Time; Cost; Sustainability	Process; Product; Environment	No Integration	Historical/ Batch	Deep Learning	6
785	(Proto et al., 2020)	Quality Control	Predictive	Conformance; Customer Satisfaction	Process; Product; Customer; Human	Vertical; Horizontal	Real-time	Classification	1
786	(Q. Bi, Wang, Wu, Zhu, & Ding, 2019)	Condition Analysis	Predictive	Time; Conformance	Machine/ Tool	No Integration	Real-time	Regression; Fuzzy Logic	4
787	(Q. Li et al., 2019)	Security/ Risk Analysis	Predictive	Cost; Security	Machine/ Tool	No Integration	Real-time	Classification; Regression; Clustering	3
788	(Q. Wang, Jiao, Wang, & Zhang, 2020)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Environment	No Integration	Real-time	Classification; Dimension Reduction	4
789	(R. Hao, Lu, Cheng, Li, & Huang, 2020)	Quality Control	Predictive	Conformance	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	1
790	(Rahman, Janardhanan, & Nielsen, 2019)	Production Planning	Descriptive	Time; Cost; Flexibility	ERP	Horizontal	Real-time	Evolutional Algorithm; Swarm Intelligence	3
791	(Rato & Reis, 2020)	Quality Control	Predictive	Conformance	Process; Product	Vertical	Historical/ Batch	Mathematical Optimization	1
792	(Rauf et al., 2020)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process	Vertical	Historical/ Batch	Mathematical Optimization; Evolutional Algorithm	2
793	(Romeo et al., 2020)	Performanc e Opt.	Predictive	Time; Cost; Conformance; Flexibility	Machine/ Tool; Product	No Integration	Historical/ Batch	Classification; Regression	1
794	(Romero-Hdz, Saha, Tstutsumi, & Fincato, 2020)	Performanc e Opt.	Prescriptive	Time; Cost	Process; Reference	No Integration	Historical/ Batch	Reinforcement Learning; Mathematical Optimization	2
795	(Rossit, Tohmé, & Frutos, 2019)	Production Planning	Prescriptive	Flexibility	Machine/ Tool; Process	Vertical; Horizontal	Real-time	Multi-Agent System	2
796	(Ruiz-Sarmiento et al., 2020)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Probabilistic Methods	6
797	(S. Choi, Youm, & Kang, 2019)	Monitoring	Descriptive	Time	Process	Vertical; Horizontal	Real-time	Multi-Agent System	3
798	(S. Li et al., 2020)	Defect Analysis	Predictive	Time; Cost	Product	No Integration	Historical/ Batch	Classification; Deep Learning	6
799	(S. Lin, He, & Sun, 2019)	Quality Control	Diagnostic	Conformance	Product	No Integration	Real-time	Classification; Dimension Reduction	1
800	(S. Ma et al., 2020)	Energy Cons. Opt.	Predictive	Cost; Sustainability	Machine/ Tool; Environment	End-to-End	Real-time	Swarm Intelligence	6
801	(S. S.-D. Xu, Huang, Kung, & Lin, 2019)	Performanc e Opt.	Prescriptive	Cost; Flexibility	Machine/ Tool; Environment	Horizontal	Real-time	Swarm Intelligence; Fuzzy Logic	2
802	(S. W. Kim, Lee, Tama, & Lee, 2020)	Monitoring	Predictive	Time; Cost	Product	No Integration	Historical/ Batch	Classification; Regression	6
803	(S.-T. Park, Li, & Hong, 2020)	Security/ Risk Analysis	Predictive	Security	Process	Vertical	Real-time	Classification; Regression; Clustering; Deep Learning; Custom Development	3
804	(Sacco, Radwan, Anderson, Harik, & Gregory, 2020)	Quality Opt.	Predictive	Cost; Conformance	Product; Reference	End-to-End	Historical/ Batch	Classification; Dimension Reduction	1

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
805	(Said, ben Abdellafou, & Taouali, 2019)	Defect Analysis	Predictive	Time; Cost; Security	Machine/ Tool; Environment	No Integration	Real-time	Regression; Dimension Reduction; Mathematical Optimization; Custom Development	4
806	(Salary et al., 2020)	Monitoring	Predictive	Time	Process	Horizontal	Real-time	Classification	3
807	(Saucedo-Dorantes, Delgado-Prieto, Osornio-Rios, & de Jesus Romero-Troncoso, 2020)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Dimension Reduction	5
808	(Saúl Langarica, Rüffelmacher, & Núñez, 2019)	Defect Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Real-time	Probabilistic Methods; Dimension Reduction	4
809	(Scalabrini Sampaio, Vallim Filho, Santos da Silva, & Augusto da Silva, 2019)	Maintenance Planning	Predictive	Conformance; Flexibility; Security	Reference; ERP	End-to-End	Historical/ Batch	Custom Development	6
810	(Shen et al., 2020)	Condition Analysis	Predictive	Time; Cost; Conformance	Machine/ Tool	No Integration	Historical/ Batch	Regression	6
811	(Ståhl, Mathiason, Falkman, & Karlsson, 2019)	Quality Control	Predictive	Cost; Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Classification; Deep Learning	1
812	(Stoyanov, Ahsan, Bailey, Wotherspoon, & Hunt, 2019)	Quality Opt.	Prescriptive	Time; Cost; Conformance	Machine/ Tool; Process	Vertical	Historical/ Batch	Classification	2
813	(Susto, Maggipinto, Zocco, & McLoone, 2019)	Performance Opt.	Prescriptive	Time; Cost	Process	No Integration	Historical/ Batch	Regression; Dimension Reduction	2
814	(T. Yu, Huang, & Chang, 2020)	Performance Opt.	Prescriptive	Time; Cost; Flexibility	Process; Human	No Integration	Historical/ Batch	Deep Learning; Reinforcement Learning	2
815	(Tabernik, Šela, Skvarč, & Skočaj, 2020)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Reference	No Integration	Real-time	Classification; Deep Learning	4
816	(Tan et al., 2019)	Production Planning	Prescriptive	Time; Cost	Process; ERP	Vertical	Historical/ Batch	Mathematical Optimization; Evolutional Algorithm	2
817	(Tang et al., 2020)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Dimension Reduction	4
818	(Unnikrishnan, Donovan, Macpherson, & Tormey, 2020)	Quality Control	Descriptive	Conformance	Environment	No Integration	Real-time	Classification	1
819	(van Staden & Boute, 2020)	Maintenance Planning	Prescriptive	Time; Cost	Machine/ Tool; Process	No Integration	Historical/ Batch	Mathematical Optimization	2
820	(Veeramani, Muthuswamy, Sagar, & Zoppi, 2019)	Performance Opt.	Prescriptive	Time; Cost; Conformance; Flexibility	Machine/ Tool; Product	No Integration	Real-time	Probabilistic Methods; Reinforcement Learning; Custom Development	2
821	(Vukicevic et al., 2019)	Quality Control	Descriptive	Time; Cost; Conformance; Customer Satisfaction	Product	No Integration	Historical/ Batch	Custom Development	1
822	(W. Du, Kang, & Pecht, 2019)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Real-time	Classification; Deep Learning; Custom Development	4
823	(W. Han, Tian, Shi, Huang, & Li, 2019)	Monitoring	Predictive	Cost	Product; Environment	No Integration	Real-time	Classification; Regression; Deep Learning	6
824	(W. J. Lee, Mendis, Triebe, & Sutherland, 2020)	Monitoring	Predictive	Conformance	Machine/ Tool	No Integration	Real-time	Classification; Probabilistic Methods; Clustering; Dimension Reduction	4
825	(W. Jiang et al., 2020)	Condition Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Historical/ Batch	Regression; Deep Learning	6
826	(W. Li, Xie, & Wang, 2018)	Security/ Risk Analysis	Descriptive	Security	Machine/ Tool	No Integration	Historical/ Batch	Classification	3
827	(W. Liu, Kong, Niu, Jiang, & Zhou, 2020)	Monitoring	Descriptive	Conformance	Process	Vertical	Real-time	Custom Development	3
828	(W. Luo, Hu, Ye, Zhang, & Wei, 2020)	Condition Analysis	Predictive	Conformance; Security	Machine/ Tool	No Integration	Real-time	Classification; Regression; Mathematical Optimization; Custom Development	4

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
829	(W. Yu, Dillon, Mostafa, Rahayu, & Liu, 2019)	Defect Analysis	Predictive	Time; Cost	Process	No Integration	Real-time	Clustering	6
830	(W. Zhu, Ma, Benton, Romagnoli, & Zhan, 2019)	Defect Analysis	Diagnostic	Time; Cost; Security	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	5
831	(X. Fang et al., 2019)	Energy Cons. Opt.	Diagnostic	Time	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	5
832	(X. Jia et al., 2019)	Security/ Risk Analysis	Prescriptive	Security; Sustainability	Environment	No Integration	Historical/ Batch	Classification; Probabilistic Methods; Deep Learning	3
833	(X. Jin, Fan, & Chow, 2018)	Defect Analysis	Predictive	Time; Cost; Flexibility	Machine/ Tool	No Integration	Historical/ Batch	Custom Development	6
834	(X. Jin, Que, Sun, Guo, & Qiao, 2019)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Probabilistic Methods; Mathematical Optimization	6
835	(X. Wu, Tian, & Zhang, 2019)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process	Vertical	Real-time	Custom Development	2
836	(X. Yan et al., 2020)	Security/ Risk Analysis	Predictive	Time; Cost; Security	Machine/ Tool	No Integration	Historical/ Batch	Classification; Regression	3
837	(Xiaoyu Zhang, Chen, Liu, & Xiang, 2019)	Security/ Risk Analysis	Prescriptive	Security	Customer	No Integration	Historical/ Batch	Deep Learning	3
838	(Xinghua Li, Xu, Vijayakumar, Kumar, & Liu, 2020)	Security/ Risk Analysis	Prescriptive	Security	Machine/ Tool	No Integration	Historical/ Batch	Classification; Deep Learning	3
839	(Xingwei Xu, Tao, Ming, An, & Chen, 2020)	Condition Analysis	Diagnostic	Time; Cost; Conformance; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Deep Learning	1
840	(Y Zhang, Beudaert, Argandoña, Ratchev, & Munoa, 2020)	Monitoring	Predictive	Time; Cost	Machine/ Tool	Vertical	Real-time	Classification; Dimension Reduction	3
841	(Y. Fu, Zhou, Guo, & Qi, 2019)	Production Planning	Prescriptive	Time; Cost	Process	No Integration	Historical/ Batch	Mathematical Optimization	2
842	(Y. Li et al., 2020)	Production Planning	Predictive	Time; Cost; Flexibility	Process; Environment	No Integration	Historical/ Batch	Classification; Mathematical Optimization	2
843	(Y. Ma, Zhu, Benton, & Romagnoli, 2019)	Monitoring	Descriptive	Time	Process	No Integration	Real-time	Deep Learning; Reinforcement Learning	3
844	(Y. Song, Li, Jia, & Qiu, 2019)	Defect Analysis	Predictive	Customer Satisfaction	Machine/ Tool; Reference	No Integration	Historical/ Batch	Classification; Dimension Reduction	6
845	(Y. Tao, Wang, Sánchez, Yang, & Bai, 2019)	Defect Analysis	Descriptive	Time; Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Classification; Regression	5
846	(Y. Xu, Sun, Liu, & Zheng, 2019)	Defect Analysis	Descriptive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Classification; Deep Learning	5
847	(Y. Yao, Wang, Long, Xie, & Wang, 2020)	Defect Analysis	Diagnostic	Time; Cost	Machine/ Tool; Process	No Integration	Historical/ Batch	Deep Learning	5
848	(Y.-C. Lin, Yeh, Chen, Liu, & Wang, 2020)	Monitoring	Predictive	Time; Cost; Flexibility; Sustainability	Machine/ Tool; Process	Vertical	Historical/ Batch	Custom Development	6
849	(Y.-T. Tsai et al., 2020)	Quality Opt.	Prescriptive	Time; Cost; Conformance; Flexibility	Machine/ Tool; Process; Product; Reference	No Integration	Real-time	Classification; Deep Learning; Reinforcement Learning; Mathematical Optimization	2
850	(Yacob, Semere, & Nordgren, 2019)	Quality Opt.	Predictive	Time; Conformance	Product	No Integration	Historical/ Batch	Classification	1
851	(Yaliang Zhao, Yang, & Sun, 2018)	Security/ Risk Analysis	Descriptive	Cost; Security	Process	Horizontal	Real-time	Clustering	3
852	(Yan Wang et al., 2019)	Defect Analysis	Predictive	Time; Cost	Process	No Integration	Historical/ Batch	Mathematical Optimization	6
853	(Yanxia Wang, Li, Gan, & Cameron, 2019)	Energy Cons. Analysis	Diagnostic	Cost; Sustainability	Machine/ Tool	No Integration	Historical/ Batch	Clustering	6
854	(Ying Zhao et al., 2019)	Quality Control	Descriptive	Conformance	Product	No Integration	Historical/ Batch	Clustering	1
855	(Yingjie Zhang, Soon, Ye, Fuh, & Zhu, 2019)	Monitoring	Diagnostic	Time; Cost; Conformance	Machine/ Tool; Process	No Integration	Historical/ Batch	Classification; Deep Learning	5
856	(Yun et al., 2020)	Quality Control	Predictive	Time; Cost; Conformance	Machine/ Tool; Reference	No Integration	Real-time	Classification; Dimension Reduction; Deep Learning	4
857	(Zenisek, Holzinger, & Affenzeller, 2019)	Condition Analysis	Predictive	Time; Cost	Machine/ Tool; Environment	No Integration	Real-time	Regression	4
858	(Zhe Li, Wang, & Wang, 2020)	Defect Analysis	Predictive	Time; Cost	Machine/ Tool	No Integration	Historical/ Batch	Regression; Deep Learning	6
859	(Zhengcai Cao, Zhou, Hu, & Lin, 2019)	Production Planning	Prescriptive	Time; Cost; Flexibility	Process; ERP	Vertical	Real-time	Probabilistic Methods; Mathematical Optimization	2

No.	Reference	Function	Maturity	Objective	Data Source	Integration	Frequency	Method	Cluster
860	(Zhifen Zhang, Yang, Ren, & Wen, 2019)	Defect Analysis	Diagnostic	Time; Cost	Environment	No Integration	Real-time	Classification	4
861	(Zhifeng Liu, Chen, Zhang, Yang, & Chu, 2019)	Maintenance Planning	Predictive	Time; Cost	Reference	Horizontal	Real-time	Custom Development	3
862	(Zhixiong Li, Liu, & Wu, 2019)	Condition Analysis	Predictive	Time; Cost; Conformance	Machine/ Tool; Environment	No Integration	Real-time	Classification; Dimension Reduction	4
863	(Zilong Cao, Zhou, Li, Huang, & Wu, 2020)	Performance Opt.	Prescriptive	Time; Conformance	Machine/ Tool	Vertical	Historical/ Batch	Reinforcement Learning	2
864	(Zolanvari, Teixeira, Gupta, Khan, & Jain, 2019)	Security/ Risk Analysis	Prescriptive	Security	Machine/ Tool	No Integration	Historical/ Batch	Classification; Regression	3
865	(Zongxin Liu & Pu, 2019)	Product Lifecycle Opt.	Diagnostic	Conformance	Machine/ Tool; Human	No Integration	Real-time	Classification	1

Appendix B – Taxonomy Building Iterations

Iteration I. For our first iteration, we identified preliminary publications (cf. Section 2.5), which aim at a holistic view, but primarily for specific questions or areas (e.g., business potentials or ML) (Bang et al., 2019; Bordeleau et al., 2018; Y. Cheng, K. Chen, et al., 2018; Diez-Olivan et al., 2019; Fay & Kazantsev, 2018; Gölzer et al., 2015; Gölzer & Fritzsche, 2017; O'Donovan et al., 2015; Sharp et al., 2018; X. Y. Xu & Hua, 2017). We used this knowledge to employ categorization schemes to derive an initial set of dimensions and characteristics.

Iteration II. In the second iteration, we focused on domain-specific preliminary publications (cf. again Section 2.5). The prerequisite for the analysis is that the respective authors prepared their data in a taxonomic or categorical fashion. We identified 16 relevant contributions (Baum et al., 2018; Bousdekis, Magoutas, Mentzas, et al., 2015; Çaliş & Bulkan, 2015; Cardin et al., 2017; Cerrada et al., 2018; Khan & Yairi, 2018; D.-H. Kim et al., 2018; G. Y. Lee et al., 2018; J. Lee, Wu, et al., 2014; Priore et al., 2014; M. S. Reis & Gins, 2017; Y. Xu et al., 2017; Zarandi, Asl, Sotudian, & Castillo, 2018a; G. Zhao et al., 2016; Y. Zhou & Xue, 2018; Zschech, 2018). We extracted our categorization from each related work and compared it with the taxonomy from the first iteration. Based on this, we added, divided, or merged dimensions and characteristics.

Iteration III. Due to the extensive structuring of the provisional taxonomy, in this iteration we decided to switch to an empirical-to-conceptual approach. We identified a total of 633 articles, which consider the use of BA within a specific smart manufacturing application case (cf. Section 4.1). We ensured possible modifications of the taxonomy and a possible post-validation by splitting the data. With a random share of 30 % (n=189) of the search results for each group, we were confirmed or even supplemented dimensions and characteristics.

Iteration IV. In the fourth iteration, we again selected a random share of 30 % (n=189) of the search results from the remaining 446 objects. Again, the objective was the validation or extension of dimensions and characteristics using the empirical-to-conceptual approach. However, the result revealed that no further modification was necessary. All closing conditions were satisfied, and we considered the development of the initial taxonomy complete.

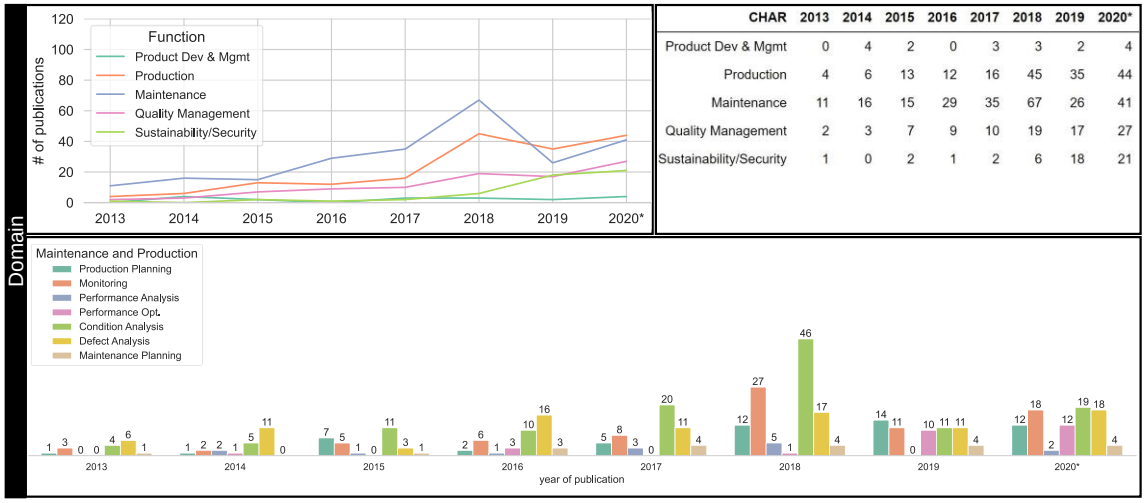
Iteration V. To reconfirm our taxonomy's general structure with new research identified in our second literature survey, we decided to perform another conceptual-to-empirical approach. We identified seven further survey papers that prepared their results in a taxonomic or categorical fashion. None take a holistic approach (see Iteration I), they are all domain-specific (see Iteration II). Taking this into account, the articles did not discuss a domain, which was not yet included in our initial taxonomy. Most authors address industrial maintenance, mostly focusing on surveying

analytics techniques (W. Zhang et al., 2019) others additionally take integration, data (Dalzochio et al., 2020) or specific maintenance functions into account (Zonta et al., 2020). H. Ding et al. (2020) employ artificial intelligence algorithms as a starting point and map these to specific use cases in maintenance and quality control. Finally, Cadavid et al. (2020) focus on production planning, but also include functions such as maintenance and product design. As the research is domain-specific, it partly addresses dimensions and characteristics on a lower granularity level. Our current taxonomy addresses these on a higher level with regard to the ending conditions (EC2.1) *concise* and (EC2.3) *comprehensive*, we did not alter the initial taxonomy.

Iteration VI. As we identified more objects on our second survey, ending condition (EC1.1) was not met anymore. Hence, we switched to an empirical-to-conceptual approach, following our procedure in the third and fourth iteration. We analyzed the 232 objects, by mapping them according to our current taxonomy. The results revealed that no further dimensions or characteristics were identifiable and all ending conditions were satisfied, as the research team was able to tag all objects successfully according to the existing dimensions and characteristics. In conclusion, the second literature search confirmed our initial taxonomy.

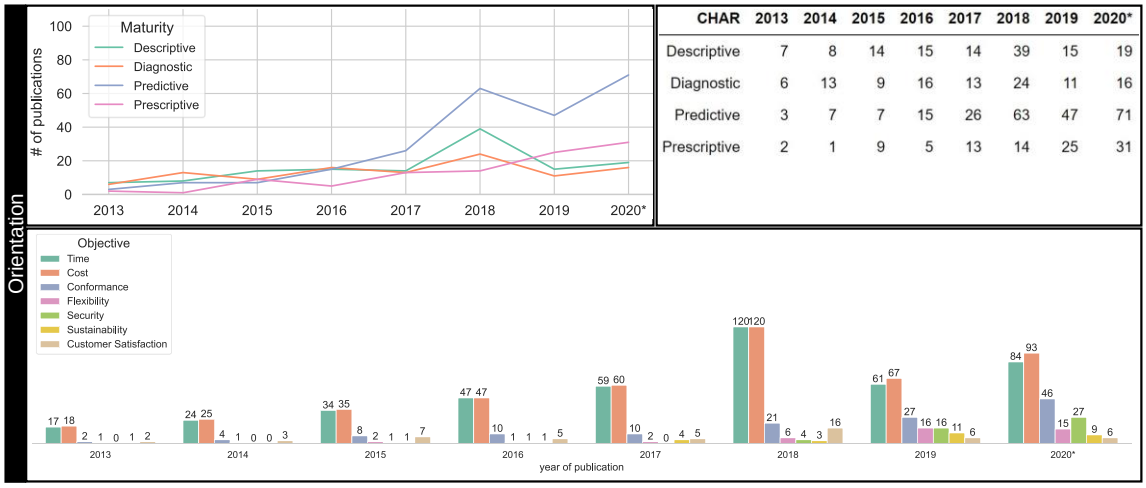
Appendix C – Analysis of Temporal Variations and Trends

C.1 Temporal Variations per Dimension



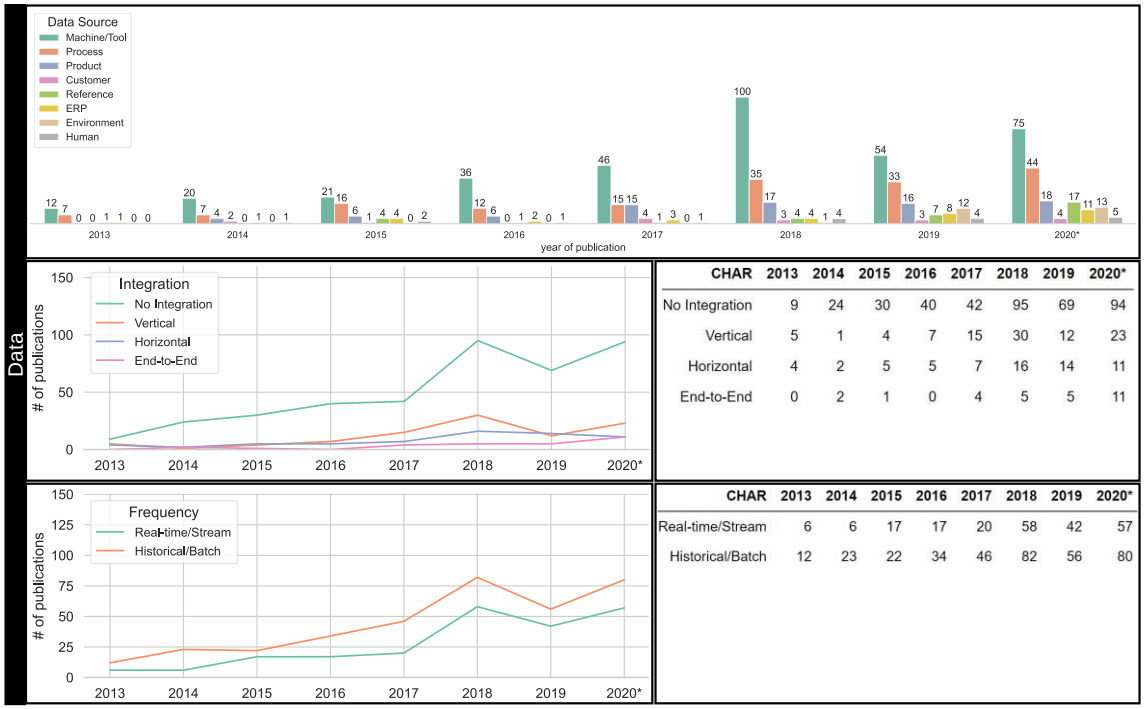
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Product Dev & Mgmt	0	4	2	0	3	3	2	4
Production	4	6	13	12	16	45	35	44
Maintenance	11	16	15	29	35	67	26	41
Quality Management	2	3	7	9	10	19	17	27
Sustainability/Security	1	0	2	1	2	6	18	21

Figure 1: Temporal Variations of the Dimension *Domain*



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	7	8	14	15	14	39	15	19
Diagnostic	6	13	9	16	13	24	11	16
Predictive	3	7	7	15	26	63	47	71
Prescriptive	2	1	9	5	13	14	25	31

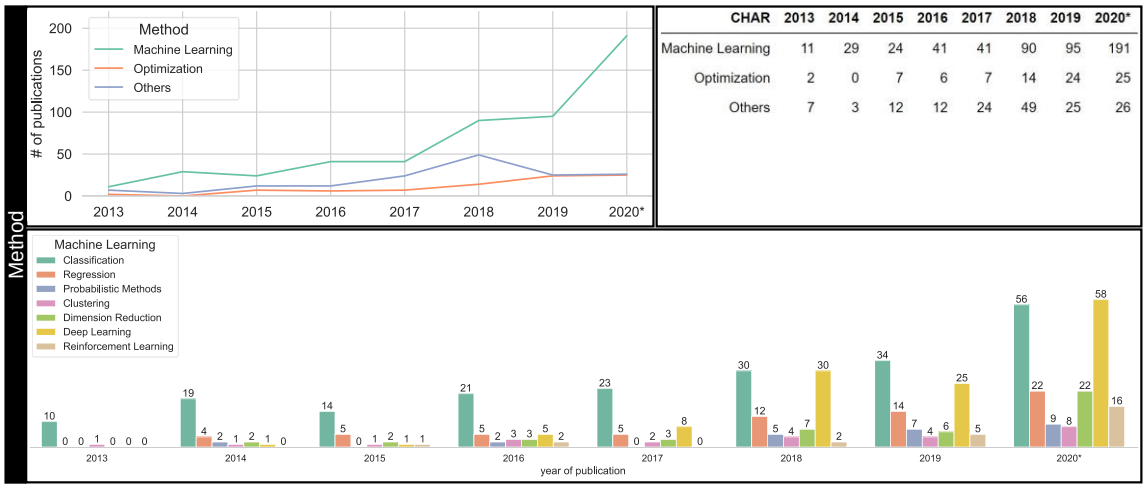
Figure 2: Temporal Variations of the Dimension *Orientation*



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
No Integration	9	24	30	40	42	95	69	94
Vertical	5	1	4	7	15	30	12	23
Horizontal	4	2	5	5	7	16	14	11
End-to-End	0	2	1	0	4	5	5	11

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Real-time/Stream	6	6	17	17	20	58	42	57
Historical/Batch	12	23	22	34	46	82	56	80

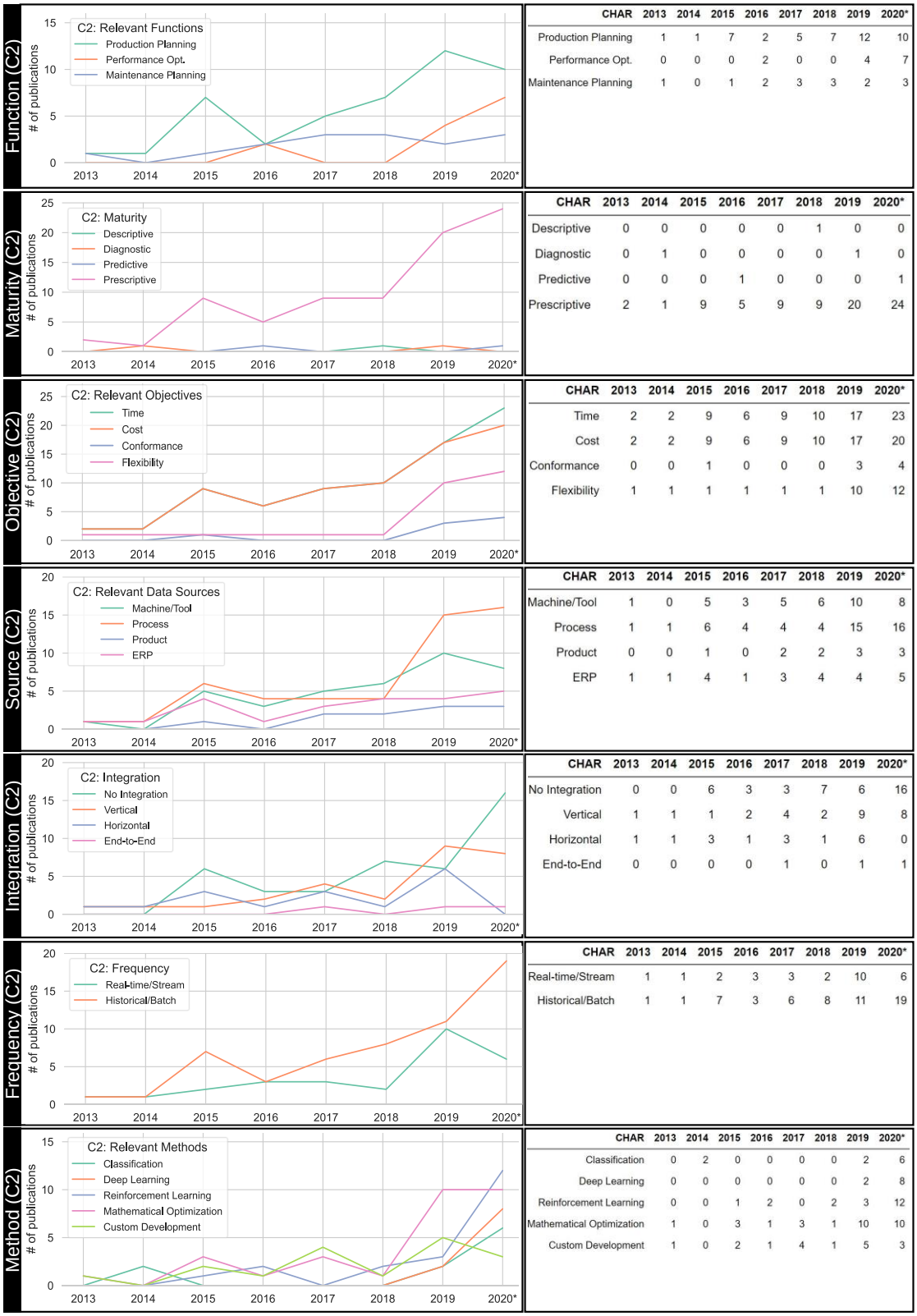
Figure 3: Temporal Variations of the Dimension *Data*



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Machine Learning	11	29	24	41	41	90	95	191
Optimization	2	0	7	6	7	14	24	25
Others	7	3	12	12	24	49	25	26

Figure 4: Temporal Variations of the Dimension *Method*

C.2 Temporal Variations per Archetype



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Production Planning	1	1	7	2	5	7	12	10
Performance Opt.	0	0	0	2	0	0	4	7
Maintenance Planning	1	0	1	2	3	3	2	3

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	0	0	0	0	0	1	0	0
Diagnostic	0	1	0	0	0	0	1	0
Predictive	0	0	0	1	0	0	0	1
Prescriptive	2	1	9	5	9	9	20	24

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Time	2	2	9	6	9	10	17	23
Cost	2	2	9	6	9	10	17	20
Conformance	0	0	1	0	0	0	3	4
Flexibility	1	1	1	1	1	1	10	12

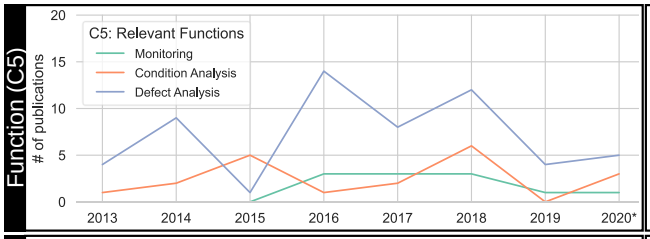
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Machine/Tool	1	0	5	3	5	6	10	8
Process	1	1	6	4	4	4	15	16
Product	0	0	1	0	2	2	3	3
ERP	1	1	4	1	3	4	4	5

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
No Integration	0	0	6	3	3	7	6	16
Vertical	1	1	1	2	4	2	9	8
Horizontal	1	1	3	1	3	1	6	0
End-to-End	0	0	0	0	1	0	1	1

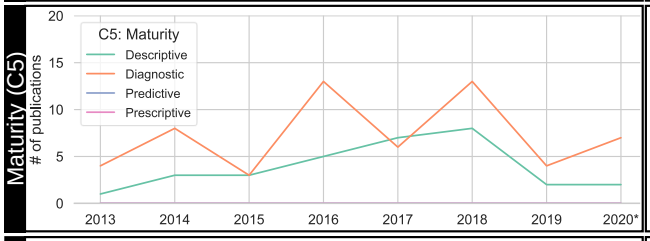
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Real-time/Stream	1	1	2	3	3	2	10	6
Historical/Batch	1	1	7	3	6	8	11	19

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Classification	0	2	0	0	0	0	2	6
Deep Learning	0	0	0	0	0	0	2	8
Reinforcement Learning	0	0	1	2	0	2	3	12
Mathematical Optimization	1	0	3	1	3	1	10	10
Custom Development	1	0	2	1	4	1	5	3

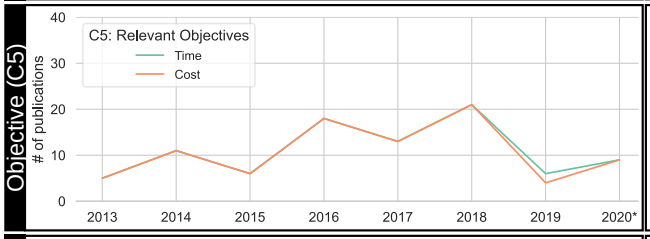
Figure 5: Temporal Variations of the Archetype *MRO Planning* (C2)



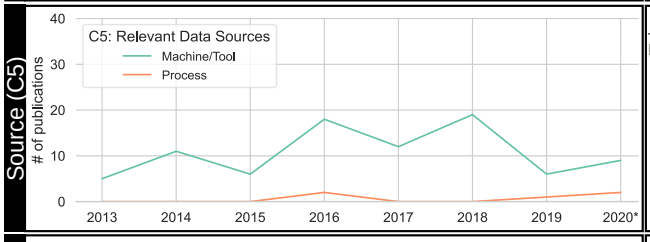
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Monitoring	0	0	0	3	3	3	1	1
Condition Analysis	1	2	5	1	2	6	0	3
Defect Analysis	4	9	1	14	8	12	4	5



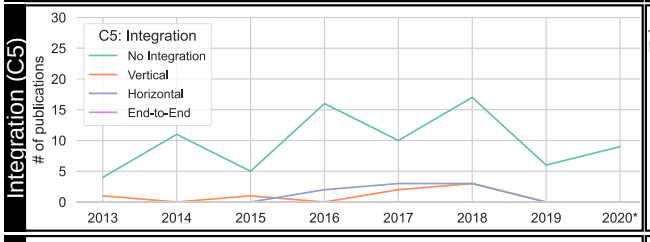
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	1	3	3	5	7	8	2	2
Diagnostic	4	8	3	13	6	13	4	7
Predictive	0	0	0	0	0	0	0	0
Prescriptive	0	0	0	0	0	0	0	0



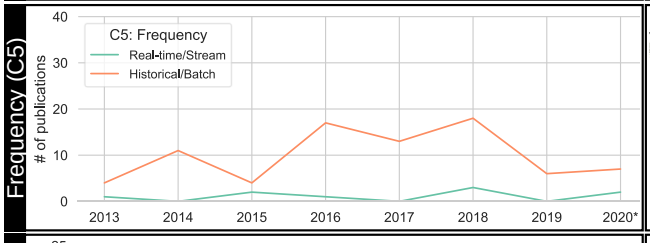
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Time	5	11	6	18	13	21	6	9
Cost	5	11	6	18	13	21	4	9



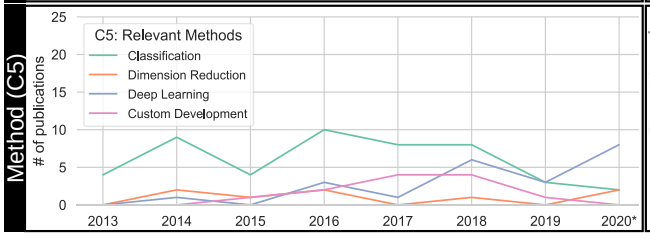
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Machine/Tool	5	11	6	18	12	19	6	9
Process	0	0	0	2	0	0	1	2



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
No Integration	4	11	5	16	10	17	6	9
Vertical	1	0	1	0	2	3	0	0
Horizontal	0	0	0	2	3	3	0	0
End-to-End	0	0	0	0	0	0	0	0

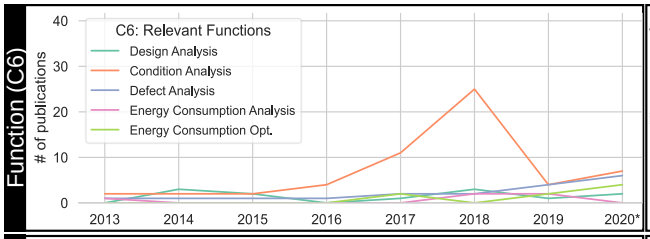


CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Real-time/Stream	1	0	2	1	0	3	0	2
Historical/Batch	4	11	4	17	13	18	6	7

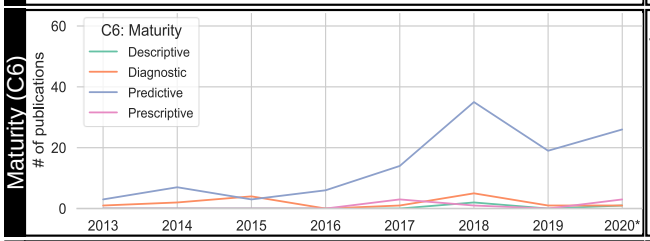


CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Classification	4	9	4	10	8	8	3	2
Dimension Reduction	0	2	1	2	0	1	0	2
Deep Learning	0	1	0	3	1	6	3	8
Custom Development	0	0	1	2	4	4	1	0

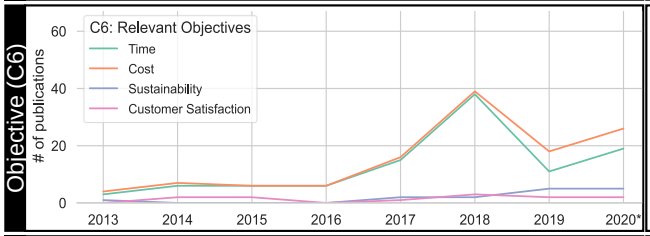
Figure 6: Temporal Variations of the Archetype *Reactive Maintenance* (C5)



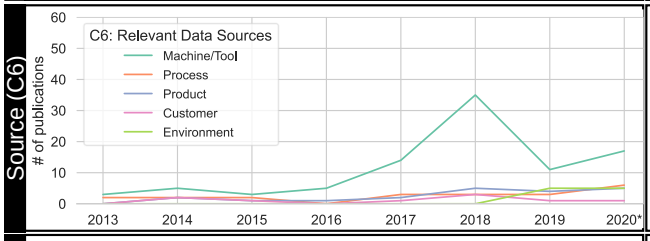
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Design Analysis	0	3	2	0	1	3	1	2
Condition Analysis	2	2	2	4	11	25	4	7
Defect Analysis	1	1	1	1	2	2	4	6
Energy Consumption Analysis	1	0	0	0	0	2	2	0
Energy Consumption Opt.	0	0	0	0	2	0	2	4



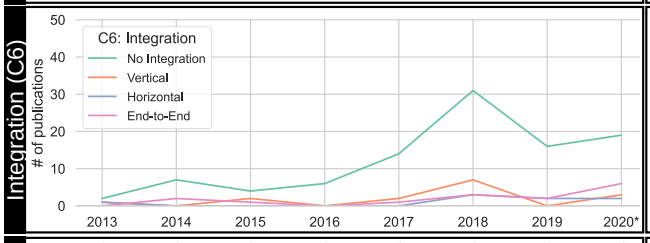
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	0	0	0	0	0	2	0	1
Diagnostic	1	2	4	0	1	5	1	1
Predictive	3	7	3	6	14	35	19	26
Prescriptive	0	0	0	0	3	1	0	3



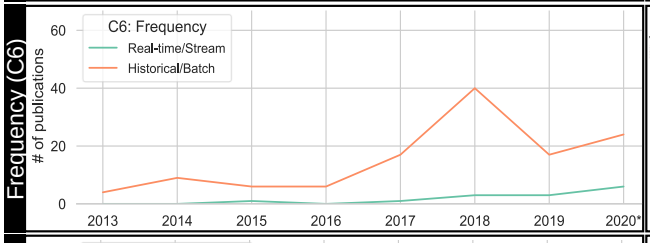
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Time	3	6	6	6	15	38	11	19
Cost	4	7	6	6	16	39	18	26
Sustainability	1	0	0	0	2	2	5	5
Customer Satisfaction	0	2	2	0	1	3	2	2



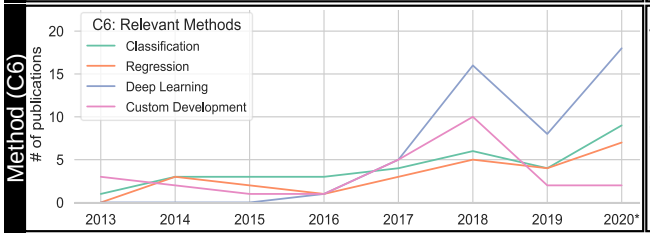
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Machine/Tool	3	5	3	5	14	35	11	17
Process	2	2	2	0	3	3	3	6
Product	0	2	1	1	2	5	4	5
Customer	0	2	1	0	1	3	1	1
Environment	0	0	0	0	0	0	5	5



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
No Integration	2	7	4	6	14	31	16	19
Vertical	1	0	2	0	2	7	0	3
Horizontal	1	0	0	0	0	3	2	2
End-to-End	0	2	1	0	1	3	2	6

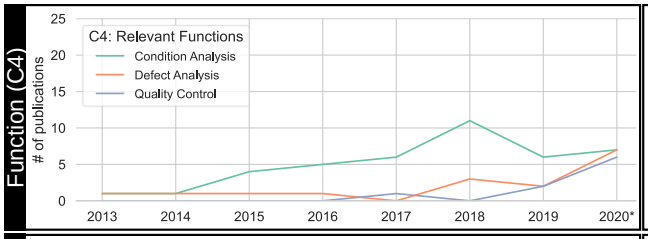


CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Real-time/Stream	0	0	1	0	1	3	3	6
Historical/Batch	4	9	6	6	17	40	17	24

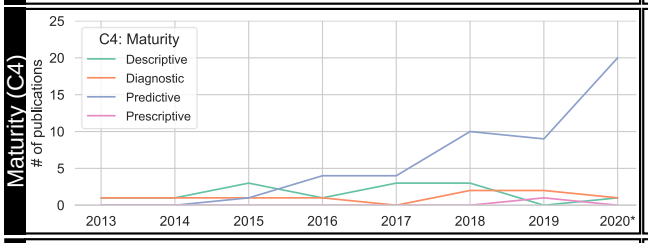


CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Classification	1	3	3	3	4	6	4	9
Regression	0	3	2	1	3	5	4	7
Deep Learning	0	0	0	1	5	16	8	18
Custom Development	3	2	1	1	5	10	2	2

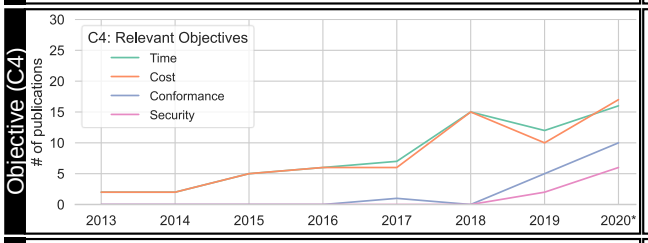
Figure 7: Temporal Variations of the Archetype *Offline Predictive Maintenance* (C6)



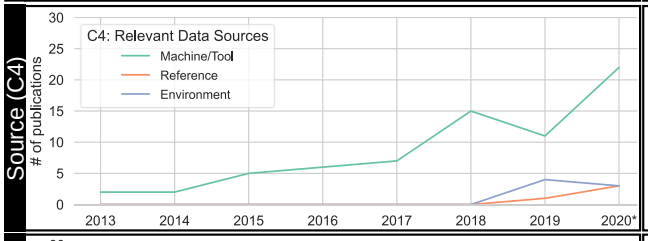
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Condition Analysis	1	1	4	5	6	11	6	7
Defect Analysis	1	1	1	1	0	3	2	7
Quality Control	0	0	0	0	1	0	2	6



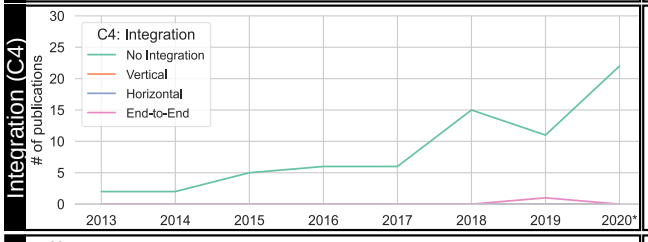
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	1	1	3	1	3	3	0	1
Diagnostic	1	1	1	1	0	2	2	1
Predictive	0	0	1	4	4	10	9	20
Prescriptive	0	0	0	0	0	0	1	0



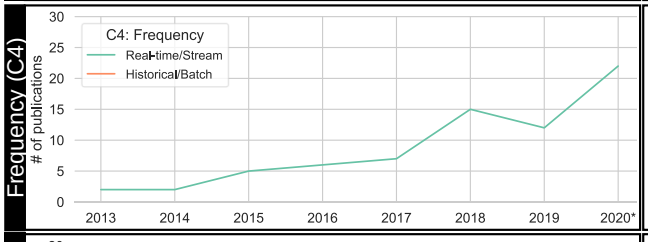
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Time	2	2	5	6	7	15	12	16
Cost	2	2	5	6	6	15	10	17
Conformance	0	0	0	0	1	0	5	10
Security	0	0	0	0	0	0	2	6



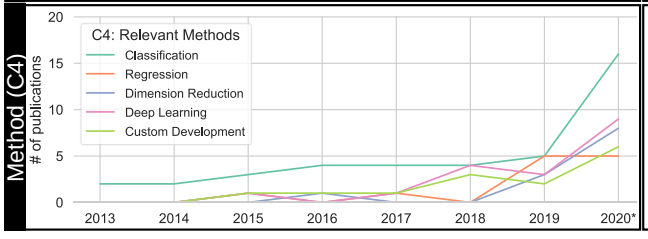
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Machine/Tool	2	2	5	6	7	15	11	22
Reference	0	0	0	0	0	0	1	3
Environment	0	0	0	0	0	0	4	3



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
No Integration	2	2	5	6	6	15	11	22
Vertical	0	0	0	0	0	0	0	0
Horizontal	0	0	0	0	0	0	0	0
End-to-End	0	0	0	0	0	0	1	0

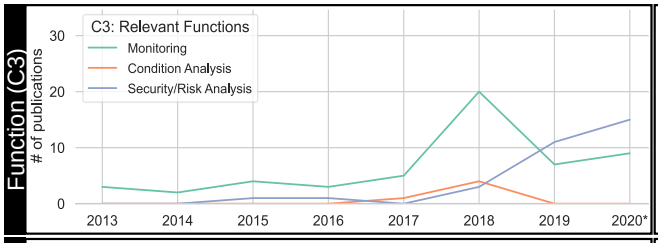


CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Real-time/Stream	2	2	5	6	7	15	12	22
Historical/Batch	0	0	0	0	0	0	0	0

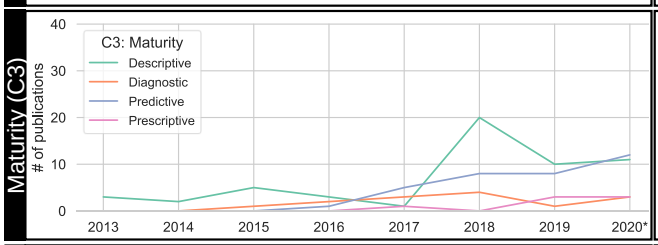


CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Classification	2	2	3	4	4	4	5	16
Regression	0	0	1	0	1	0	5	5
Dimension Reduction	0	0	0	1	0	0	3	8
Deep Learning	0	0	1	0	1	4	3	9
Custom Development	0	0	1	1	1	3	2	6

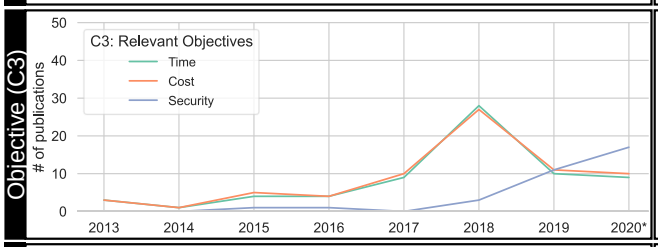
Figure 8: Temporal Variations of the Archetype *Online Predictive Maintenance* (C4)



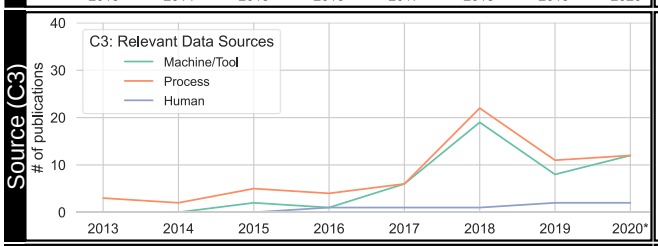
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Monitoring	3	2	4	3	5	20	7	9
Condition Analysis	0	0	0	0	1	4	0	0
Security/Risk Analysis	0	0	1	1	0	3	11	15



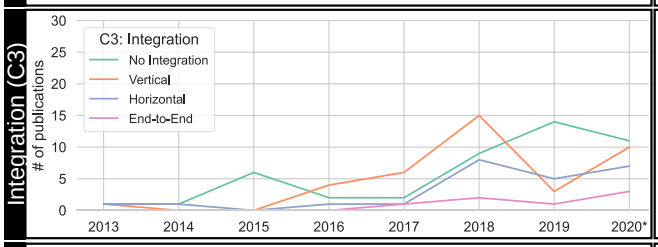
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	3	2	5	3	1	20	10	11
Diagnostic	0	0	1	2	3	4	1	3
Predictive	0	0	0	1	5	8	8	12
Prescriptive	0	0	0	0	1	0	3	3



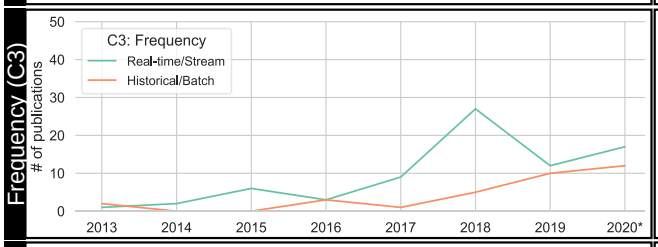
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	3	2	5	3	1	20	10	11
Diagnostic	0	0	1	2	3	4	1	3
Predictive	0	0	0	1	5	8	8	12
Prescriptive	0	0	0	0	1	0	3	3



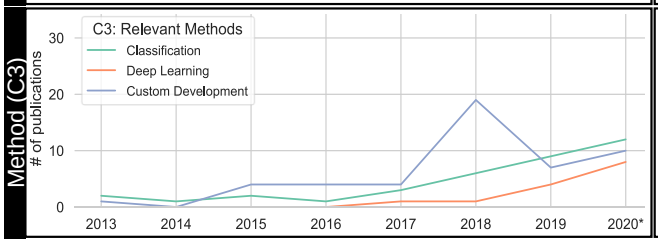
CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Machine/Tool	0	0	2	1	6	19	8	12
Process	3	2	5	4	6	22	11	12
Human	0	0	0	1	1	1	2	2



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
No Integration	1	1	6	2	2	9	14	11
Vertical	1	0	0	4	6	15	3	10
Horizontal	1	1	0	1	1	8	5	7
End-to-End	0	0	0	0	1	2	1	3

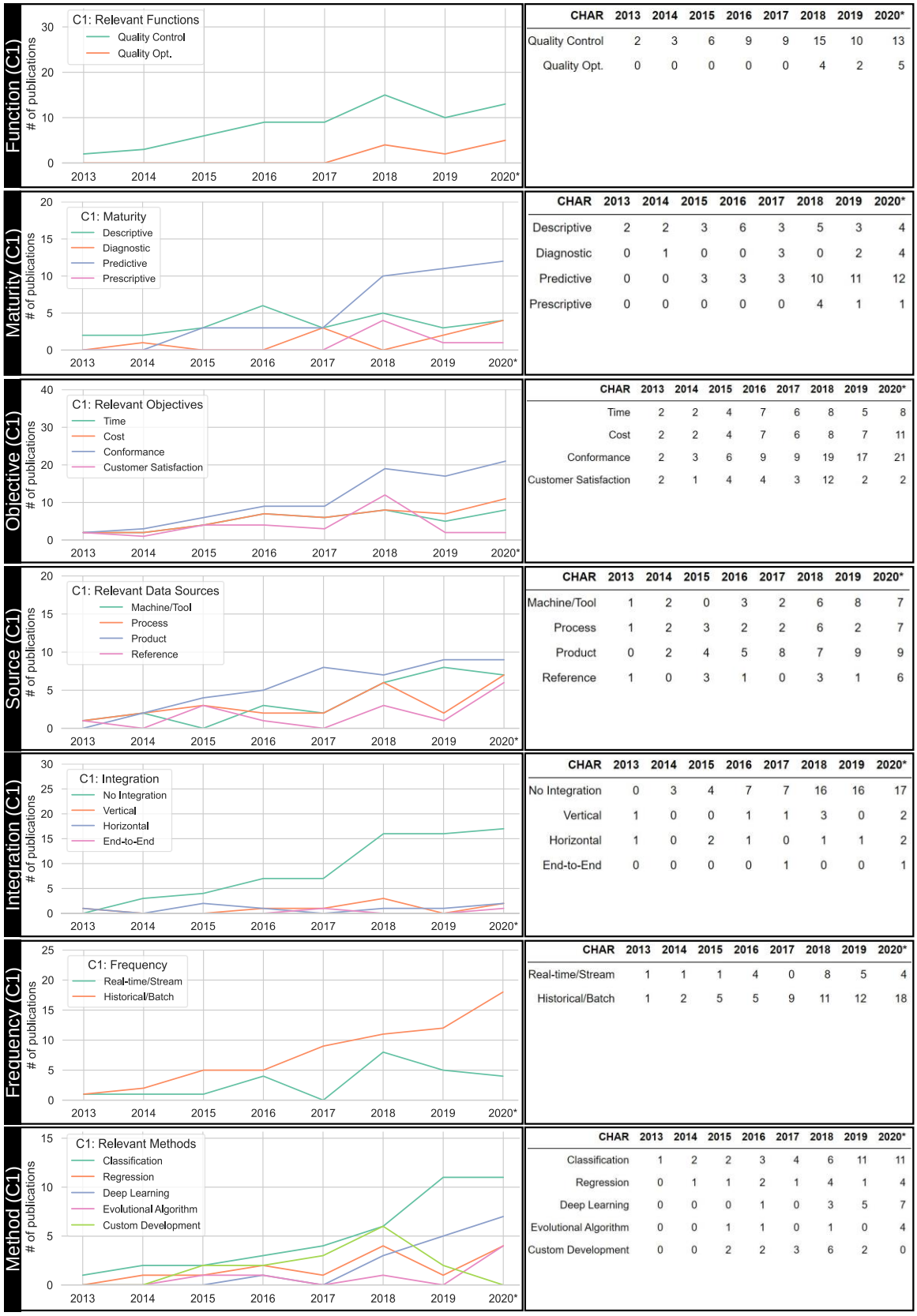


CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Real-time/Stream	1	2	6	3	9	27	12	17
Historical/Batch	2	0	0	3	1	5	10	12



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Classification	2	1	2	1	3	6	9	12
Deep Learning	0	0	0	0	1	1	4	8
Custom Development	1	0	4	4	4	19	7	10

Figure 9: Temporal Variations of the Archetype *MRO Monitoring* (C3)



CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Quality Control	2	3	6	9	9	15	10	13
Quality Opt.	0	0	0	0	0	4	2	5

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Descriptive	2	2	3	6	3	5	3	4
Diagnostic	0	1	0	0	3	0	2	4
Predictive	0	0	3	3	3	10	11	12
Prescriptive	0	0	0	0	0	4	1	1

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Time	2	2	4	7	6	8	5	8
Cost	2	2	4	7	6	8	7	11
Conformance	2	3	6	9	9	19	17	21
Customer Satisfaction	2	1	4	4	3	12	2	2

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Machine/Tool	1	2	0	3	2	6	8	7
Process	1	2	3	2	2	6	2	7
Product	0	2	4	5	8	7	9	9
Reference	1	0	3	1	0	3	1	6

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
No Integration	0	3	4	7	7	16	16	17
Vertical	1	0	0	1	1	3	0	2
Horizontal	1	0	2	1	0	1	1	2
End-to-End	0	0	0	0	1	0	0	1

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Real-time/Stream	1	1	1	4	0	8	5	4
Historical/Batch	1	2	5	5	9	11	12	18

CHAR	2013	2014	2015	2016	2017	2018	2019	2020*
Classification	1	2	2	3	4	6	11	11
Regression	0	1	1	2	1	4	1	4
Deep Learning	0	0	0	1	0	3	5	7
Evolutional Algorithm	0	0	1	1	0	1	0	4
Custom Development	0	0	2	2	3	6	2	0

Figure 10: Temporal Variations of the Archetype *Quality Management* (C1)

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