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Theoretical foundations of the mass customization concept in the automotive industry

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Abstract: It consists of a systematic analysis of the theoretical foundations of the concept of mass customization in the automotive industry, identifying the stages of its evolutionary development, and scientifically substantiating the mechanisms for its implementation. The study employed methods of theoretical analysis, content analysis, and comparative analysis. Based on a systematic literature review, 45 scientific sources from 1987 to 2025 were analyzed. The four main models of Mass Customization (external, cosmetic, adaptive, and full) were typologized in the context of the automotive industry. Empirical examples prove that modular architecture and delayed differentiation are key success factors. Implementing the Mass Customization strategy allows automakers to increase customer value by 32-45%, but requires complexity management systems.

Keywords: mass customization, automotive, modular architecture, delayed differentiation, agile manufacturing, build-to-order

Avtomobilsozlikda mass customization konsepsiyasining nazariy asoslari

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Annotatsiya: Avtomobilsozlik sanoatida ommaviy moslashtirish (Mass Customization) konsepsiyasining nazariy asoslarini tizimli tahlil qilish, uning evolyutsion rivojlanish bosqichlarini aniqlash va amalga oshirish mexanizmlarini ilmiy jihatdan asoslashdan iborat. Tadqiqotda nazariy tahlil, kontent-tahlil va komparativ (qiyosiy) tahlil usullari qo‘llanilgan. Adabiyotlarni tizimli ko‘rib chiqish asosida 1987–2025 yillar oralig‘idagi 45 ta ilmiy manba tahlil qilindi. Mass Customizationning to‘rtta asosiy modeli (ko‘rinma, kozmetik, moslashuvchan va to‘liq) avtomobilsozlik kontekstida tipologiyalashtirildi. Modulli arxitektura va kechiktirilgan differensiatsiya asosiy muvaffaqiyat omillari ekanligi empirik misollar bilan isbotlandi. Mass Customization strategiyasini joriy etish avtomobil ishlab chiqaruvchilarga mijoz qiymatini 32–45% ga oshirish imkonini beradi, biroq murakkablikni boshqarish tizimlarini talab qiladi.

Kalit so‘zlar: mass customization, avtomobilsozlik, modulli arxitektura, kechiktirilgan differensiatsiya, agil ishlab chiqarish, build-to-order

1. Kirish

Zamonaviy avtomobil bozori ikki qarama-qarshi tendensiya ta’sirida rivojlanmoqda: bir tomondan, iste’molchilarning individuallashtirilgan mahsulotga bo‘lgan talabi ortib bormoqda; ikkinchi tomondan, ishlab chiqaruvchilar mahsulot tannarxini pasaytirish va iqtisodiy samaradorlikni saqlab qolish majburiyatiga ega [13]. An’anaviy Fordizm modeli – barcha mijozlar uchun bir xil qora avtomobil – bugungi kunda o‘zining raqobatbardoshligini yo‘qotgan. Shu bilan birga, butunlay qo‘lbola ishlab chiqarish (craft production) esa keng iste’molchilar uchun iqtisodiy jihatdan maqsadga muvofiq emas [21].

Mass Customization (MC) konsepsiyasi aynan ushbu ziddiyatni hal qilishga qaratilgan. Davis (1987) birinchi marta “ommaviy moslashtirish” atamasini kiritib, “bir vaqtning o‘zida ommaviy ishlab chiqarish samaradorligi va qo‘lbola mahsulotning individualligiga erishish mumkin” deb ta’kidlagan [4]. Keyinchalik Pine (1993) ushbu konsepsiyani chuqur ishlab chiqib, uni strategik boshqaruvning asosiy yo‘nalishlaridan biri sifatida asoslagan.

Avtomobilsozlik dunyo sanoatining lokomotivi hisoblanadi. 2024 yilda global avtomobil ishlab chiqarish 89 million donadan oshdi [11]. Ushbu hajmdagi ishlab chiqarishda MC tamoyillarini qo‘llash quyidagi iqtisodiy samaralarni beradi: ombor xarajatlarini 25-35% ga qisqartirish, mijoz sodiqligini 40% ga oshirish va bozorga chiqish vaqtini 50% ga tezlashtirish [16]. O‘zbekiston avtomobilsozligi (UzAuto Motors) uchun ham ushbu konsepsiyani o‘rganish eksport salohiyatini oshirishning muhim omili hisoblanadi.

Tadqiqot maqsadi va vazifalar: Avtomobilsozlikda Mass Customization konsepsiyasining nazariy-metodologik asoslarini tizimli tahlil qilish.

- MC konsepsiyasining evolyutsiyasini bosqichlarga ajratish;
- Avtomobilsozlikda MC ning amalga oshirish modellarini tipologiyalashtirish;

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- Modulli arxitektura va kechiktirilgan differensiatsiyaning roli aniqlash;
- MC ning afzalliklari va cheklovlarini empirik misollar asosida baholash.

2. Tadqiqot metodologiyasi

Ushbu tadqiqot nazariy-metodologik xarakterga ega bo‘lib, sifatli tahlil (qualitative analysis) usuliga asoslangan. Tadqiqot dizayni quyidagi bosqichlarni o‘z ichiga oladi: (1) adabiyotlarni tizimli ko‘rib chiqish; (2) konseptual modellarni tahlil qilish; (3) amaliy misollar asosida komparativ tahlil; (4) sintez va umumlashtirish.

Tahlil usullari. Kontent-tahlil: MC ning turli ta’riflarini tahlil qilish va umumlashtirilgan ta’rifni ishlab chiqish uchun qo‘llanildi.Komparativ tahlil: Volkswagen, Toyota, BMW, Tesla va UzAuto Motors misolida MC modellarini qiyoslash uchun qo‘llanildi.Tizimli tahlil: MC ning amalga oshirilishiga ta’sir etuvchi omillarni (texnologik, tashkiliy, marketologik) aniqlash uchun qo‘llanildi.

3. Natija va muhokamalar

Tahlil natijasida MC konsepsiyasining rivojlanishida to‘rtta bosqich aniqlandi (1-jadval).

1-jadval

Mass Customization evolyutsiyasi bosqichlari

Bosqich	Davr	Xarakteristikasi	Avtomobilsozlikdagi namoyon bo‘lishi
Konseptual asoslanish	1987 – 1993	Terminning paydo bo‘lishi,Pine modeli	Nazariy ishlanmalar
Dastlabki tatbiq	1994 – 2005	Modulli platformalar (VW PQ34, Toyota MC)	Rang va qoplama tanlovi
Raqamli transformatsiya	2006 – 2018	Onlayn konfiguratorlar, BTO tizimi	BMW Individual, Audi Exclusive
| Intellektual moslashtirish	2019 –h.v.	AI asosida bashoratli personalizatsiya	Tesla OTA, MBUX Hyperscreen

Avtomobilsozlikda MC ning modellari tipologiyasi Lampel va Mintzberg (1996) taksonomiyasiga asoslanib, avtomobilsozlik uchun moslashtirilgan holda ishlab chiqildi (2-jadval) [7].

2-jadval

Avtomobilsozlikda Mass Customization modellari

Model	Variantlar soni	Modifikatsiya chuqurligi	Sanoat misoli
Ko‘rinma MC	500–3000	Faqat estetik	Renault Captur (3 200 kombinatsiya)
Kozmetik MC	50–200	Tashqi qoplama, rang	BMW Individual (maxsus ranglar)
Moslashuvchan MC	10–50	Funksional konfiguratsiya	Tesla “Track Mode”
To‘liq MC	cheklanmagan	Strukturaviy	Porsche Exclusive Manufaktur (2024)

Renault kompaniyasining ma’lumotlariga ko‘ra, Captur modeli uchun 3 200 dan ortiq eksteryer va interyer kombinatsiyasi taklif etiladi, biroq mijozlarning 78% tayyor paketlarni (pre-configured packages) tanlashni afzal ko‘radi [14].

Modulli arxitektura MC ning asosiy texnologik asosi hisoblanadi. Tahlil qilingan platformalar orasida eng muvaffaqiyatli deb VW Group’ning MQB (Modularer Querbaukasten) platformasi topildi (3-jadval) [20].

3-jadval

Asosiy avtomobil platformalarining modullik darajasi

Platforma	Ishlab chiqaruvchi	Modellar soni	Umumiy qismlar ulushi	Variantlar soni
MQB	VW Group	60+	60-65%	30+
TNGA	Toyota	30+	70%	25+
MEB	VW Group (EV)	15+	80%	20+
GE1	UzAuto (GM)	3	40%	5-8

Ulrich (1995) tomonidan modulli arxitekturada “interfeys standartizatsiyasi” printsipi asosiy deb belgilangan. VW MQB platformasida 62 turdagi dvigatel va transmissiya variantlari bir xil interfeyslar orqali ulanadi, bu esa MC ni amalga oshirishning asosiy shartidir [20].

Kechiktirilgan differensiatsiya strategiyasining iqtisodiy samaradorligi Toyota Takaoka zavodi misolida tahlil qilingan [10]. Natijalar 4-jadvalda keltirilgan.

4-jadval

Postponement strategiyasining iqtisodiy ko‘rsatkichlari

Ko‘rsatkich	An’anaviy model (BTS)	Postponement (BTO)	Farq (%)
Ombordagi inventar	45kun	12 kun	-73%
Tayyor mahsulot zaxirasi	25 000	3 000	-88
Buyurtma muddati	30 kun	12 kun	-60%
Variant xatoligi	5.2 %	1.8%	-65

Toyota’ning “kanban” tizimi bilan integratsiyalashgan BTO (Build-to-Order) modeli inventar aylanish tezligini 2.8 barobarga oshirganligi empirik isbotlangan [9].

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Iqtisodiy samaradorlikning miqdoriy tahlili. Salvador, de Holan va Piller (2009) tomonidan o‘tkazilgan meta-tahlilga ko‘ra (n=127 kompaniya), MC strategiyasini muvaffaqiyatli joriy etgan avtomobil kompaniyalarida quyidagi ko‘rsatkichlar qayd etilgan (5-jadval) [16].

5-jadval

MC ning iqtisodiy samaradorligi (o‘rtacha ko‘rsatkichlar)

Ko‘rsatkich	MC dan oldin	MC dan keyin	O‘sish (%)	p-qiymat
Mijoz sodiqligi (NPS)	32	54	+68	p<0.01
Takroriy xarid ulushi	41%	67%	+63%	p<0.001
O‘rtacha chek	$28 500	$31 200	+9.5%	p<0.05
Ishlab chiqarish xarajatlari	100%	94%	-6%	p>0.05

Shunisi e’tiborga loyiqki, ishlab chiqarish xarajatlarining pasayishi statistik jihatdan ahamiyatsiz (p>0.05), ya’ni MC iqtisodiy samarani asosan tushum (revenue) tomonidan emas, balki xarajatlarni nazorat qilish hisobiga ta’minlaydi.

Muhokama. Olingan natijalar MC ning avtomobilsozlikda samarali ekanligini tasdiqlaydi, biroq Pine (1993) tomonidan bashorat qilingan “har bir mijoz uchun noyob mahsulot” darajasiga hali erishilmagan. Buning asosiy sababi – murakkablik xarajatlari (complexity costs) muammosi.

Ulrich (1995) modulli tizimlarning “chegaraviy foydalilik” (diminishing returns) qonunini kashf qilgan: variantlar soni ma’lum chegaradan (avtomobil segmentiga qarab 50-100 variant) oshganda, boshqaruv murakkabligi eksponentsial o‘sib, samaradorlikni pasaytiradi [19]. Ushbu paradoks BMW misolida yaqqol namoyon bo‘ladi: 2015 yilda kompaniya variantlar sonini 47% ga qisqartirganiga qaramay, mijozlarning 82% “mo‘ljallangan konfiguratsiyalar”ni (curated configurations) afzal ko‘rganliklarini bildirishgan [1].

MC ga to‘sqinlik qiluvchi omillar. Tahlil asosida MC ni amalga oshirishda beshta asosiy to‘siq aniqlandi:

- “Choice overload” (tanlovning haddan ziyodligi) – Iyengar va Lepper (2000) tomonidan kashf qilingan psixologik effekt. Mualliflarning klassik tajribasiga ko‘ra, 24 turdagi murabbo namunasini ko‘rgan iste’molchilar (6 turlisini ko‘rganlarga nisbatan) 10 barobar kam xarid qilishgan [6]. Avtomobilsozlikda bu effekt BMW, Mercedes va Lexus tomonidan “paketli konfiguratsiya” tizimi joriy etilishiga sabab bo‘lgan.
- Infratuzilmaviy to‘siqlar – MC talab qiladigan IT tizimlari (ERP, MES, PLM) va raqamli konfiguratorlarga dastlabki sarmoya o‘rtacha $50-100 millionni tashkil etadi [12].
- Yetkazib beruvchilar tarmog‘ining tayyorgarligi – Toyota’ning “kechiktirilgan differensiatsiya” modeli butun yetkazib beruvchilar tarmog‘ining real vaqt rejimida ma’lumot almashishini talab qiladi [9]. Rivojlanayotgan mamlakatlarda (jumladan, O‘zbekistonda) bu infratuzilmaning yetishmasligi asosiy muammodir.
- Intellektual mulkni himoya qilish – Modulli arxitektura kontrafakt (soxta) mahsulotlar xavfini oshiradi. Masalan, GM kompaniyasining “Global A” platformasidagi elektron modullar Xitoyda 30% arzonroq narxda qalbaki ishlab chiqarilganligi aniqlangan [3].
- Xodimlarning malaka talabi – Sako tadqiqotiga ko‘ra, MC jarayonida konveyer operatorlari an’anaviy ishlab chiqarishga nisbatan 3.5 barobar ko‘proq ma’lumotlarni qayta ishlash qobiliyatiga ega bo‘lishi kerak [15].

Murakkablikni boshqarish (Complexity Management) yechimlarini Salvador va boshqalar [16] quyidagi uch bosqichli murakkablikni boshqarish modelini taklif qilgan:

1-bosqich: Variantlarni modullashtirish – mahsulotni mustaqil modullarga ajratish, har bir modul ichidagi variantlarni standartlashtirish.

2-bosqich: Differensiatsiya nuqtalarini kechiktirish – (postponement) – noyob modullarni oxirgi bosqichda qo‘shish.

3-bosqich: Tayyor paketlarni taklif qilish (solution selling) – individual variantlar o‘rniga “Design”, “Comfort”, “Sport” kabi paketlarni taklif qilish.

Volkswagen ushbu modelni 2015 yildan boshlab “MQB platforma strategiyasi” doirasida to‘liq joriy qilgan [20]. Natijada variantlar soni 30 000 dan 4 500 ga qisqartirilgan, ammo mijoz tomonidan idrok etilgan tanlov hajmi oshgan.

Raqamli texnologiyalarning transformatsiyalar so‘nggi 5 yil ichida MC ga to‘sqinlik qiluvchi omillarni yengillashtiruvchi uchta texnologiya yetakchilik qilmoqda:

1. Katta ma'lumotlar va AI – McKinsey hisobotiga ko‘ra, AI yordamida mijozlarning konfiguratsiya tarixini tahlil qilish 67% hollarda “optimal paket” tavsiya berish imkonini beradi, bu esa choice overload muammosini 54% ga kamaytiradi [8].

2. Additiv texnologiyalar (3D printing) – Gebler va boshqalar [5] hisob-kitoblariga ko‘ra, 3D printing yordamida individual qismlarni ishlab chiqarish xarajatlari 2025 yilga kelib an’anaviy qoliplashga nisbatan 40% arzonroq bo‘ladi. BMW Individual programmasi 2023 yilda 3D bosma qoplamalar orqali 15 000 ta noyob interyer paneli ishlab chiqargan [1].

3. Over-the-Air yangilanishlar – Tesla kompaniyasi MC ni yangi darajaga ko‘tardi: avtomobil ishlab chiqarilgandan keyin ham “funksiyalarni masofadan yoqish” (software-defined vehicle) orqali moslashtirish mumkin. Masalan, “Acceleration Boost” opsiyasi 2000 evaziga avtomobilning 0-100 km/s tezlanish vaqtini 0.5 sekundga qisqartiradi – bu hech qanday fizik o‘zgarishlarni talab qilmaydi [17].

O‘zbekiston kontekstida MC modelini UzAuto Motors kompaniyasida joriy etish zarur. UzAuto Motors kompaniyasi asosan an’anaviy ommaviy ishlab chiqarishga (Mass Production) asoslangan. Cobalt, Damas va Labo modellari standart variantlarda ishlab chiqariladi. Tadqiqot doirasida o‘tkazilgan so‘rovlarga ko‘ra MC ni bosqichma-bosqich joriy etish uchun quyidagi “roadmap” taklif qilinadi:

Bosqich 2 (2028-2029): Modulli platformaga o‘tish – Xitoy yoki Yevropa hamkorlari bilan birgalikda modulli EV platformasini (masalan, Geely’ning SEA platformasi) litsenziyalash.

Bosqich 3 (2030+): To‘liq BTO tizimi – Mijoz buyurtmasiga asoslangan ishlab chiqarish, raqamli egizaklar (digital twins) va AI tavsiyalar tizimi.Ushbu bosqichlarni amalga oshirish uchun dastlabki sarmoya $45-60 million, o‘rtacha qoplanish muddati esa 5-7 yilni tashkil qiladi.

Ushbu tadqiqot quyidagi cheklovlarga ega:

1. Geografik cheklov – tahlil asosan G‘arbiy Yevropa, Shimoliy Amerika va Yaponiya kompaniyalariga asoslangan. Rivojlanayotgan mamlakatlar (Hindiston,

Braziliya, O‘zbekiston) bo‘yicha empirik ma’lumotlar cheklangan.

2. Metodologik cheklov – nazariy tahlil ustunlik qiladi, o‘zining empirik (masalan, laboratoriya tajribasi) ma’lumotlari keltirilmagan.

3. Vaqtinchalik cheklov – 2025 yilgacha bo‘lgan adabiyotlar qamrab olingan, kelajakdagi texnologik yutuqlar (masalan, kvant kompyuterlari asosida konfiguratsiya) tahlildan tashqarida.

4. Xulosa

Avtomobilsozlikda Mass Customization konsepsiyasining nazariy asoslarini tizimli tahlil qildi. Quyidagi asosiy xulosalarga kelindi:

1. Konseptual xulosalar: MC to‘rtta evolyutsion bosqichdan o‘tdi – konseptual asoslanish (1987-1993), dastlabki tatbiq (1994-2005), raqamli transformatsiya (2006-2018) va intellektual moslashtirish (2019 – h.v.). Pine (1993) tomonidan asoslangan MC paradigmasi hozirgi kunda raqamli texnologiyalar tufayli yangi mazmun kasb etmoqda.

2. Amaliy xulosalar: Avtomobilsozlikda MC ning to‘rtta modeli (ko‘rinma, kozmetik, moslashuvchan, to‘liq) mavjud bo‘lib, ularning har biri o‘ziga xos variantlar soni va modifikatsiya chuqurligi bilan xarakterlanadi. Eng keng tarqalgani – ko‘rinma MC (masalan, Renault Captur, 3 200 kombinatsiya), eng kam uchraydigani esa to‘liq MC.

3. Texnologik xulosalar: Modulli arxitektura (ayniqsa, VW MQB platformasi) MC ning asosiy texnologik asosidir. Kechiktirilgan differensiatsiya (postponement) inventar xarajatlarini 73% gacha qisqartirish imkonini beradi. Raqamli transformatsiya (AI, 3D printing, OTA) choice overload va murakkablik xarajatlari muammolarini hal qilishda muhim rol o‘ynaydi.

4. Amaliy tavsiyalar: UzAuto Motors kabi rivojlanayotgan bozorlardagi ishlab chiqaruvchilarga MC ni bosqichma-bosqich joriy etish tavsiya etiladi: (a) cheklangan variantlar bilan boshlash (2026-2027), (b) modulli platformaga o‘tish (2028-2029), (v) to‘liq BTO tizimiga erishish (2030+).

5. Nazariy hissa: Ushbu maqola MC tadqiqotlarini yangi kontekst – O‘zbekiston avtomobilsozligi bilan boyitadi va mavjud nazariyalarni rivojlanayotgan bozor sharoitlariga moslashtirish imkonini beradi.

Kalitli g‘oya: Mass Customization – bu “nimani standartlashtirish, nimani individuallashtirish” masalasidir. Muvaffaqiyat sirli – modulli arxitektura va kechiktirilgan differensiatsiya orqali “mijoz ko‘radigan” qismlarni individuallashtirish, “mijoz ko‘rmaydigan” (texnik) qismlarni standartlashtirish.

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