



PROTEKSI ISI LAPORAN AKHIR PENELITIAN FUNDAMENTAL - REGULER

Dilarang menyalin, menyimpan, memperbanyak sebagian atau seluruh isi proposal ini dalam bentuk apapun kecuali oleh pengusul dan pengelola administrasi pengabdian kepada masyarakat

LAPORAN AKHIR

Rencana Pelaksanaan Penelitian Fundamental - Reguler: tahun 2024 s.d. tahun 2024

1. JUDUL PENELITIAN

Keberlanjutan Wirausaha berbasis Lingkungan: Peran Artificial Intelligence, Sumber Pengetahuan dan Frugal Innovation.

Bidang Fokus	Tema	Topik (jika ada)	Prioritas Riset
Sosial Humaniora, Pendidikan, Seni, Dan Budaya	Ekonomi dan sumber daya manusia	Kewirausahaan, koperasi, dan UMKM	Green Economy

Rumpun Ilmu Level 1	Rumpun Ilmu Level 2	Rumpun Ilmu Level 3
ILMU EKONOMI	ILMU EKONOMI	Akuntansi

Skema Penelitian	Strata (Dasar/Terapan/Pengembangan)	Nilai SBK	Target Akhir TKT	Lama Kegiatan
Penelitian Fundamental - Reguler	Riset Dasar	150.000.000	3	1 Tahun

2. IDENTITAS PENGUSUL

Nama, Peran	Jenis	Program Studi/Bagian	Bidang Tugas	ID Sinta
PRIYASTIWI 0522106801 Ketua Pengusul Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha	Dosen	Manajemen	Memilih dan menetapkan topik, membuat keputusan dari fase perencanaan hingga pelaporan, serta bekerja sama dengan rekan dan tim peneliti untuk menjalankan penelitian dan mengelola semua tahapan proses penelitian mulai dari awal sampai selesai.	6061161
NUR WIDIASTUTI 0518086801 Anggota Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha	Dosen	Manajemen	Menyusun kajian teori, merancang instrumen penelitian, mengumpulkan data lapangan, memproses data, menganalisis data, menarik kesimpulan, menyusun laporan dan artikel untuk publikasi, serta menyediakan materi diseminasi.	6034005
USWATUN CHASANA 0520046601 Anggota Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha	Dosen	Manajemen	Menyusun kajian teori, merancang instrumen penelitian, mengumpulkan data lapangan, memproses data, menganalisis data, menarik kesimpulan, menyusun laporan dan artikel untuk publikasi, serta menyediakan materi diseminasi.	5998431
DWI NOVITASARI 0504118202	Dosen	Manajemen	Menyusun kajian teori, merancang instrumen	5995714

Nama, Peran	Jenis	Program Studi/Bagian	Bidang Tugas	ID Sinta
Anggota Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha			penelitian, mengumpulkan data lapangan, memproses data, menganalisis data, menarik kesimpulan, menyusun laporan dan artikel untuk publikasi, serta menyediakan materi diseminasi.	
LILIK AMBARWATI 0526049301 Anggota Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha	Dosen	Akuntansi	Menyusun kajian teori, merancang instrumen penelitian, mengumpulkan data lapangan, memproses data, menganalisis data, menarik kesimpulan, menyusun laporan dan artikel untuk publikasi, serta menyediakan materi diseminasi.	6728389
WAWAN SADTYO NUGROHO 0623058303 Anggota Universitas Muhammadiyah Magelang	Dosen	Akuntansi	Mengkaji teori, merancang instrumen penelitian, mengumpulkan data lapangan, memproses data, menganalisis data, menarik kesimpulan, menyusun laporan dan artikel untuk publikasi, serta menyediakan materi diseminasi. Menjadi mitra penelitian.	6034648

3. MITRA KERJASAMA PENELITIAN (Jika Ada)

Pelaksanaan penelitian dapat melibatkan mitra kerjasama yaitu mitra kerjasama dalam melaksanakan penelitian, mitra sebagai calon pengguna hasil penelitian, atau mitra investor

Mitra	Nama Mitra	Dana
Universitas Muhammadiyah Magelang	Dr. Wawan Sadtyo Nugroho, SE., M.Si	Tahun 1 Rp 0

4. LUARAN DAN TARGET CAPAIAN

Luaran Wajib

Tahun Luaran	Kategori Luaran	Jenis Luaran	Status target capaian	Keterangan
1	Artikel di Jurnal	Artikel di Jurnal Bereputasi Internasional	Accepted/Published	https://journalsojs3.fe.up.pt/index.php/jim Nama Jurnal: Journal of Innovation Management Penerbit: Associação Journal of Innovation Management

5. ANGGARAN

Rencana Anggaran Biaya penelitian mengacu pada PMK dan buku Panduan Penelitian dan Pengabdian kepada Masyarakat yang berlaku.

Total RAB 1 Tahun Rp101.980.000,00

Tahun 1 Total Rp101.980.000,00

Kelompok	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
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Kelompok	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Pengumpulan Data	Biaya konsumsi	Diskusi penyusunan instrumen penelitian	OH	25	80.000	2.000.000
Pengumpulan Data	Transport	Diskusi penyusunan instrumen penelitian	OK (kali)	5	250.000	1.250.000
Bahan	Bahan Penelitian (Habis Pakai)	Tinta printer	Unit	6	680.000	4.080.000
Pengumpulan Data	Tiket	Tiket ke 5 Perguruan Tinggi subjek penelitian	OK (kali)	4	3.000.000	12.000.000
Analisis Data	Biaya analisis sampel	Biaya Analisis Sampel	Unit	5	1.540.000	7.700.000
Pengumpulan Data	Biaya konsumsi	Konsumsi Kegiatan Wawancara	OH	25	150.000	3.750.000
Sewa Peralatan	Kendaraan	Sewa Kendaraan Lokal	OK (kali)	15	600.000	9.000.000
Pengumpulan Data	Penginapan	Pelaksanaan Konsinyering/ Persamaan Persepsi	OH	10	750.000	7.500.000
Pelaporan Hasil Penelitian dan Luaran Wajib	Biaya Pendaftaran KI	Poster (HKI)	Paket	1	2.000.000	2.000.000
Pelaporan Hasil Penelitian dan Luaran Wajib	Uang harian rapat di luar kantor	Transport dan Konsumsi rapat/diskusi penyusunan Laporan	OH	40	80.000	3.200.000
Pengumpulan Data	HR Pembantu Lapangan	3 Mahasiswa	OH	75	80.000	6.000.000
Analisis Data	Transport Lokal	Transport Lokal (Keperluan Analisis Data)	OK (kali)	10	500.000	5.000.000
Pengumpulan Data	HR Petugas Survei	3 Mahasiswa	OH/OR	360	25.000	9.000.000
Sewa Peralatan	Peralatan penelitian	Sewa Audio Visual	Unit	5	2.000.000	10.000.000
Bahan	ATK	Kertas, Ballpoint, Spidol, Clipper	Paket	3	500.000	1.500.000
Pelaporan Hasil Penelitian dan Luaran Wajib	Biaya Publikasi artikel di Jurnal Bereputasi Internasional	Publish Jurnal Internasional (Journal of Innovation Management)	Paket	1	10.000.000	10.000.000
Pengumpulan Data	Transport	Transport Lokal	OK (kali)	8	1.000.000	8.000.000

*. KEMAJUAN PENELITIAN

A. RINGKASAN

Penelitian ini bertujuan untuk mengembangkan model keberlanjutan wirausaha berbasis lingkungan melalui integrasi kecerdasan buatan, sumber pengetahuan, dan inovasi frugal guna mendukung pencapaian Tujuan Pembangunan Berkelanjutan. Penelitian dilakukan secara bertahap, mencakup pengumpulan literatur, pengembangan model teoretis, serta analisis data menggunakan metode kuantitatif berbasis survei dan Structural Equation Models (SEM). Target luaran mencakup publikasi ilmiah, produk inovasi, dan penguatan strategi kewirausahaan hijau. Hasil menunjukkan bahwa pengetahuan, teknologi AI, dan inovasi frugal memiliki hubungan positif terhadap keberlanjutan wirausaha, dengan inovasi frugal sebagai mediator yang signifikan, sementara kepribadian berperan pada pengambilan keputusan strategis.

B. KATA KUNCI

AI; Frugal; Inovasi, Keberlanjutan; Wirausaha

Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan ringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

C. HASIL PELAKSANAAN PENELITIAN: Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian meliputi data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

Penelitian ini berjudul “Keberlanjutan Wirausaha berbasis Lingkungan: Peran *Artificial Intelligence*, Sumber Pengetahuan, dan *Frugal Innovation*”. Penelitian ini bertujuan untuk mengembangkan model yang holistik dan aplikatif guna mendukung keberlanjutan wirausaha berbasis lingkungan. Selain itu, penelitian ini juga bertujuan untuk meningkatkan jumlah usaha berbasis lingkungan, menawarkan solusi terhadap berbagai kendala serta tantangan yang dihadapi oleh usaha kecil di Indonesia, dan mendukung pencapaian Tujuan Pembangunan Berkelanjutan (*Sustainable Development Goals/SDGs*) yang telah ditetapkan oleh pemerintah. Berdasarkan peta jalan (*roadmap*) dan jadwal penelitian, tahapan pelaksanaan penelitian pada tahun 2024 secara garis besar meliputi:

- a. Persiapan dan perencanaan
Tahapan ini mencakup identifikasi dan perumusan faktor-faktor utama yang memengaruhi keberlanjutan wirausaha berbasis lingkungan. Aktivitas yang dilakukan meliputi pengumpulan dan analisis literatur dari berbagai sumber yang relevan, seperti jurnal ilmiah, artikel berita daring, buku teks, serta data statistik dari lembaga resmi, seperti Badan Pusat Statistik (BPS). Hasil dari tahapan ini akan menjadi dasar dalam merumuskan kerangka penelitian.
- b. Pengembangan model keberlanjutan wirausaha berbasis lingkungan
Tahap ini, fokus penelitian adalah membangun model keberlanjutan wirausaha berbasis lingkungan, yang disebut *Green Entrepreneurship Sustainability* (GES). Model ini akan melibatkan peran utama dari *Frugal Innovation* (FI), *Artificial Intelligence* (AI), *Knowledge Sources* (KS), serta *Personality Traits* (PT). Aktivitas yang dilakukan meliputi pengembangan kerangka teori, perancangan desain penelitian, serta pengidentifikasian kebaruan ilmiah melalui analisis celah (*gap analysis*) dari penelitian-penelitian terdahulu.

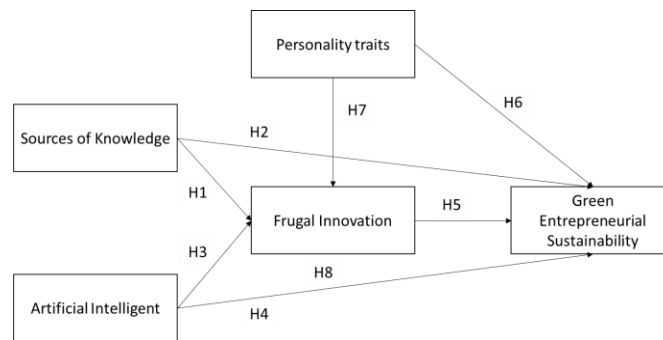
Berikut ini adalah rincian aktivitas dalam pelaksanaan penelitian:

- a. Merumuskan masalah penelitian.
 1. Kurangnya rasio wirausaha berbasis lingkungan guna menciptakan usaha ramah lingkungan, pekerjaan layak dan meningkatkan kesejahteraan.
 2. Belum meluasnya penerapan FI, pemanfaatan AI dan penggunaan sumber pengetahuan yang tepat.
 3. Model hubungan antara SDM, teknologi dan FI untuk mendukung keberlanjutan wirausaha berbasis lingkungan masih belum komprehensi.
 4. Indonesia masih menghadapi antangan SDGs yaitu inovasi dan penggunaan teknologi.
- b. Penyusunan kerangka teoretis.
Berdasarkan studi literatur ditemukan celah penelitian dan menjadi dasar kerangka teoretis (Gambar 1. Kerangka Teoretis Penelitian). Kerangka teoretis dibangun berdasarkan teori Resource-Based View (RBV) dan Job Demand Resources (JD-R).

Teori RBV menekankan pentingnya pemanfaatan sumber daya internal perusahaan yang unik, bernilai tinggi, sulit ditiru, dan tidak tergantikan untuk menciptakan keunggulan kompetitif jangka panjang. Sumber daya ini meliputi aset fisik, keahlian, serta kapabilitas organisasi. AI, sebagai teknologi yang meniru kemampuan kognitif manusia, mampu meningkatkan efisiensi, kualitas, dan wawasan bisnis melalui analisis data kompleks. Dalam kerangka RBV, AI dapat dianggap sebagai sumber daya strategis yang memungkinkan perusahaan mengelola aset dengan lebih efektif, menyesuaikan diri dengan perubahan pasar, dan meningkatkan keberlanjutan usaha. Integrasi AI juga membantu dalam mengidentifikasi pola, mengotomasi tugas rutin, dan memperluas fokus pada aktivitas yang lebih strategis, sehingga mendukung pencapaian keunggulan kompetitif yang berkelanjutan. Sisi lain, pendekatan JD-R mengaitkan dampak ganda AI dalam pekerjaan. Di satu sisi, AI dapat meningkatkan tuntutan pekerjaan melalui kompleksitas tugas dan ketidakpastian terkait perubahan teknologi, yang dapat memicu kecemasan karyawan. Namun, AI juga berfungsi sebagai sumber daya pekerjaan yang mendukung efisiensi, mempercepat pengambilan keputusan, dan meningkatkan keterampilan karyawan untuk beradaptasi dengan lingkungan berbasis teknologi. Selain itu, AI mendukung keberlanjutan dengan mengurangi limbah, mengelola sumber daya lebih baik, dan menciptakan proses ramah lingkungan. Konsep FI juga relevan dalam konteks RBV, karena memungkinkan perusahaan menciptakan solusi berkualitas tinggi dengan biaya rendah, sambil memanfaatkan sumber daya secara efisien dan berkelanjutan. Kombinasi AI, FI, dan prinsip RBV dapat memperkuat strategi usaha yang inklusif dan berorientasi pada pembangunan berkelanjutan, menciptakan

nilai ekonomi sekaligus memberikan kontribusi sosial melalui inovasi yang efisien dan berdaya saing tinggi (1–4).

Penelitian tentang AI berfokus pada pemanfaatannya dalam pengolahan data serta penerapannya di bidang pendidikan dan kesehatan (5,6). Studi terkait FI umumnya mengkaji dampaknya terhadap perubahan ekonomi dan tantangan lingkungan (7–10). Namun, penelitian yang mengaitkan sumber pengetahuan dan ciri kepribadian dengan FI belum pernah dilakukan sebelumnya. FI sering dianggap sebagai anteseden atau hasil akhir (9), tetapi belum ada studi yang menempatkan FI sebagai variabel mediasi. Sementara itu, kepribadian dalam literatur sebelumnya lebih sering diperlakukan sebagai anteseden (11), dan belum ada penelitian yang menggunakan kepribadian sebagai variabel moderasi dalam model yang melibatkan FI, KS, AI, dan GES.



Gambar 1. Kerangka Teoretis Penelitian.

(Sumber: Kajian Literatur, 2024)

c. Perumusan hipotesis penelitian.

Sumber pengetahuan, baik internal maupun eksternal, memiliki peran penting dalam mendorong inovasi frugal (FI), khususnya dalam aspek fungsionalitas dan efisiensi biaya. Pengetahuan internal, seperti pengalaman dan kompetensi karyawan, berkontribusi positif terhadap budaya inovasi, sementara pengetahuan eksternal dari pelanggan atau pemasok membantu perusahaan mengambil keputusan berisiko untuk menciptakan inovasi yang hemat biaya. Penelitian juga menunjukkan bahwa pengetahuan eksternal sering kali memiliki dampak lebih besar terhadap keberlanjutan kinerja UMKM, dengan FI berfungsi sebagai mediator antara pengelolaan pengetahuan dan keberlanjutan usaha. Para manajer UMKM disarankan untuk meningkatkan kemampuan inovasi melalui pemanfaatan teknologi informasi dan pengelolaan sumber pengetahuan secara strategis, sehingga dapat menghadapi tantangan lingkungan yang dinamis dan mencapai keberlanjutan dalam ekonomi hijau ((12–14).

Penerapan teknologi berbasis AI di negara-negara berkembang memiliki potensi untuk menciptakan solusi yang hemat biaya. Pengetahuan tentang kewirausahaan dianggap memiliki peran vital dalam mendorong inovasi hemat khususnya di negara berkembang. Inovasi hemat mendorong para wirausaha di negara berkembang untuk menemukan solusi yang efisien dan hemat biaya guna menghadapi tantangan perkembangan lingkungan yang mendesak dengan cara yang kreatif (15). Pemanfaatan teori berbasis pengetahuan dalam studi yang mendukung pengembangan inovasi hemat terbukti memiliki pengaruh kuat (16). Berdasarkan sudut pandang perusahaan di pasar negara berkembang, inovasi hemat sangat penting karena memungkinkan perusahaan menciptakan solusi yang efisien dan terjangkau, sesuai dengan kebutuhan dan keterbatasan sumber daya. Kemampuan perusahaan untuk meningkatkan inovasi hemat dapat didorong melalui pemanfaatan sumber daya pengetahuan yang tepat dan kepemimpinan (17,18). Berdasarkan penelitian sebelumnya maka dirumuskan hipotesis 1:

H1: knowledge source berpengaruh positif pada frugal innovation.

Hasil studi menunjukkan bahwa jaringan sosial memiliki pengaruh besar untuk memperoleh pengetahuan yang akhirnya menciptakan keberhasilan dalam kewirausahaan (19). Pengetahuan yang luas dari eksternal dapat melengkapi pengetahuan teknologi tradisional dari perusahaan yang sudah mapan dan mempengaruhi keberlanjutan usaha berikutnya (20). Wirausahawan yang berpengetahuan luas berperan krusial dalam menciptakan pasar bagi produk, layanan, serta model bisnis inovatif (21). Penelitian tentang kewirausahaan berbasis pengetahuan sebagian besar berfokus pada peran aktivitas intensif pengetahuan untuk pertumbuhan ekonomi, sementara studi kewirausahaan berkelanjutan terutama menyoroti isu sosial dan lingkungan yang mendorong tindakan kewirausahaan. Namun, nyatanya isu sosial dan lingkungan semakin mempengaruhi dimensi ekonomi dalam penciptaan nilai, sementara aktivitas berbasis pengetahuan dapat berperan penting tidak hanya dalam pertumbuhan ekonomi, tetapi juga dalam mengatasi masalah sosial dan lingkungan dengan memungkinkan pertukaran pengetahuan antar aktor organisasi. Sejalan dengan perspektif berbasis sumber daya, penyatuan konsep wirausaha berbasis pengetahuan dan keberlanjutan dilakukan dengan mengembangkan argumen teoretis tentang usaha baru dapat meningkatkan keunggulan kompetitif melalui

inisiatif yang berorientasi pada keberlanjutan, dengan mengembangkan sumber daya yang dikoordinasikan bersama aktor lain di ekosistem usaha (22). Berdasarkan kajian literatur maka rumusan hipotesis 2 adalah:

H2: *knowledge source berpengaruh positif pada green entrepreneurial sustainability.*

Usaha yang fokus pada digitalisasi tertentu yaitu kecerdasan buatan dapat mengatasi keterbatasan sumber daya dengan kesiapan dalam menggunakan AI. Penggunaan AI secara strategis dapat mendukung upaya FI dan meningkatkan daya saing di pasar global serta perlunya mengalokasikan sumber daya untuk mengembangkan keterampilan internal atau menggunakan keahlian eksternal guna memaksimalkan potensi AI dalam inovasi yang berkelanjutan dan hemat biaya (23). Pemahaman tentang konsep AI dan tingkat investasi AI adalah faktor keberhasilan yang paling berpengaruh dalam mengadopsi AI secara efektif dan penerapan inovasi hemat (24). Usaha dan perusahaan memiliki potensi besar untuk berkontribusi pada pembangunan berkelanjutan melalui penciptaan pengetahuan dan lapangan kerja. Namun, dampak usaha terhadap lingkungan ekologis dan sosial sering kali diabaikan, sehingga diperlukan kewirausahaan sebagai penggerak transformasi menuju bioekonomi yang lebih berkelanjutan. Studi menunjukkan bahwa ekosistem kewirausahaan yang mendukung inovasi dan keberlanjutan sangat penting, meskipun kebijakan pemerintah yang tidak selaras dengan kebutuhan pelanggan dapat menjadi penghambat. Kolaborasi antara akademisi, industri, dan pemerintah diperlukan untuk meningkatkan kecanggihan bisnis dan menarik investasi, meski tantangan seperti keterbatasan pasar domestik dan kebijakan transfer pengetahuan yang rumit masih perlu diatasi. Kewirausahaan berbasis pengetahuan terbukti dapat memperkuat ketahanan ekonomi lokal dan mendorong kemajuan sosial, sehingga kebijakan yang mendukung inovasi dan kewirausahaan lokal menjadi krusial. Mengabaikan pengetahuan sebagai sumber daya strategis dapat menghambat upaya mencapai tujuan pembangunan berkelanjutan (25–27). Rumusan hipotesis yang ke tiga adalah:

H3: *Artificial intelligence berpengaruh positif pada frugal innovation.*

AI merupakan salah satu solusi untuk praktik ramah lingkungan di berbagai bidang strategis, namun penting untuk mengintegrasikan praktik AI dengan perhatian terhadap lingkungan, agar dapat mempromosikan masa depan yang lebih ramah lingkungan dan efisien energi untuk sistem AI (28). AI diharapkan menjadi instrumen penting untuk menciptakan, menangkap, dan memberikan nilai dalam keberlanjutan lingkungan. Inovasi model bisnis yang didorong oleh AI dapat mendukung masyarakat dalam mewujudkan masa depan ramah lingkungan yang lebih berkelanjutan (29). AI juga dianggap sebagai faktor pendorong inovasi dan pengembangan berkelanjutan (30). Sebuah studi mengungkapkan bahwa kecerdasan buatan (AI) dapat membantu usaha kecil dan menengah (UKM) untuk memperluas pasar mereka ke tingkat internasional dengan memperkuat inovasi frugal, yakni penciptaan produk dan layanan berkualitas tinggi dengan biaya rendah. Meski AI bukan syarat utama, teknologi ini memungkinkan UKM mengubah model bisnis mereka untuk meningkatkan daya saing global. Inovasi frugal, yang menjadi solusi bagi berbagai tantangan bisnis kecil terutama di negara berkembang, dinilai mampu mendukung pencapaian tujuan pembangunan berkelanjutan (SDGs) dengan memanfaatkan keterbatasan sebagai peluang. Penelitian juga menunjukkan bahwa kombinasi AI dan inovasi frugal dapat mendorong pertumbuhan ekonomi yang inklusif dan berkelanjutan, sekaligus mengurangi dampak negatif terhadap lingkungan, sehingga memperkuat kontribusi UKM terhadap bioekonomi global (23,31). Berdasarkan literatur terdahulu maka hipotesis dirumuskan yaitu:

H4: *Artificial intelligence berpengaruh positif pada green entrepreneurial sustainability.*

Hasil penelitian terdahulu menunjukkan bahwa FI pada usaha kecil yang semakin besar akan memberikan kontribusi pada keberlanjutan usaha (32). FI memiliki potensi dalam mendorong hasil keberlanjutan yang dipengaruhi oleh aktor yang mengembangkan inovasi, bentuk organisasi (perusahaan besar, perusahaan kecil), lokasi geografisnya (asing atau lokal), serta motivasinya (lebih berorientasi pada keuntungan atau tujuan sosial) (33). Turbulensi dari pasar maupun teknologi, membuat keberlanjutan organisasi atau perusahaan bergantung pada inovasi pekerjaan, dukungan kelembagaan, infrastruktur, kecanggihan pasar, modal manusia, kecanggihan bisnis, dan riset serta pengembangan tentang FI (34). Temuan studi lainnya menunjukkan bahwa inovasi dengan AI merupakan elemen penting kewirausahaan yang menghubungkan semua topik dan tujuan dari Pembangunan Berkelanjutan (SDGs). AI memiliki potensi untuk meningkatkan efisiensi dan efektivitas dalam berbagai sektor, termasuk kesehatan, pertanian, dan manajemen sumber daya, dengan memberikan solusi inovatif untuk tantangan lingkungan dan sosial. Namun, ada tantangan yang dihadapi, seperti isu etika, ketidaksetaraan, dan dampak lingkungan dari penerapan teknologi AI (35,36).

H5: *Frugal innovation berpengaruh positif pada green entrepreneurial sustainability.*

Temuan studi terdahulu menyatakan bahwa ciri kepribadian pendiri usaha berperan penting dalam memotivasi pendirian usaha berbasis lingkungan. Pendiri yang memiliki ciri kepribadian terbuka atau ekstrovert cenderung memulai usaha ramah lingkungan dan kepribadian mempengaruhi inovasi produk dan proses usaha berbasis lingkungan (37). Studi lainnya menemukan bahwa ciri kepribadian proaktif dari generasi-Z memiliki pengaruh terhadap niat keberlanjutan berwirausaha dan praktik bisnis berbasis lingkungan di kalangan generasi muda (38). Ciri kepribadian berperan penting dalam motivasi memulai usaha dan pertumbuhan usaha kecil berbasis lingkungan (39). Temuan penelitian terdahulu juga memberikan penekanan pentingnya adopsi perilaku ramah lingkungan dan frugal innovation untuk meningkatkan kinerja

usaha, serta perlunya budaya manajemen pengetahuan untuk mendukung keberhasilan dan keberlanjutan di pasar yang semakin kompetitif. Hubungan antara inovasi frugal dan keberlanjutan, serta dampaknya terhadap kinerja, terutama di kalangan usaha kecil dan menengah (UKM) juga menjadi topik di studi sebelumnya. Inovasi frugal, yang ditandai dengan efisiensi sumber daya dan biaya rendah, dapat berkontribusi pada praktik bisnis yang lebih berkelanjutan. Hasil menunjukkan bahwa adopsi teknologi informasi dan komunikasi (TIK) serta budaya kolaboratif dalam organisasi dapat meningkatkan kemampuan inovasi frugal, yang pada gilirannya mendukung keberlanjutan dan kinerja usaha. Selain itu, artikel ini menyoroti tantangan dan peluang yang dihadapi oleh UKM dalam mengintegrasikan inovasi frugal dengan strategi keberlanjutan, serta pentingnya kepemimpinan dan berbagi pengetahuan dalam proses tersebut. Transformasi teknologi dan peran inovasi frugal dalam pengembangan kewirausahaan di negara berkembang, dapat mempengaruhi konsep dan praktik pengembangan teknologi dan sebagai solusi yang terjangkau serta berkelanjutan (32,40,41).

Berdasarkan serangkaian studi terdahulu maka rumusan hipotesis adalah:

H6: Personality traits berpengaruh positif pada green entrepreneurial sustainability.

Studi tentang moderasi PT dalam keberlanjutan wirausaha masih sangat terbatas, namun ada beberapa studi yang relevan dengan konteks ini. Studi terdahulu menemukan bahwa AI dapat mempengaruhi cara kerja individu dengan sifat atau ciri kepribadian gelap (*machiavellianism*, narsistik dan psikopat) dalam bidang usaha dan pekerjaan tertentu (42). Hasil studi lainnya menunjukkan bahwa faktor individu yaitu kewajiban moral dan spiritual sangat berpengaruh pada niat kewirausahaan berkelanjutan, baik secara langsung maupun tidak langsung (43). Rumusan hipotesis adalah:

H7: Personality traits memoderasi pengaruh sources of knowledge, artificial intelligent dan frugal innovation pada green entrepreneurial sustainability.

Peran FI sebagai mediasi dalam studi terdahulu masih terbatas, tetapi ada studi yang terkait dengan konteks ini. FI adalah solusi untuk masalah keberlanjutan. Hal ini mendorong desain yang sederhana dan ramah lingkungan. Teknologi yang tepat dan FI membantu pembangunan berkelanjutan (44). Pentingnya pengetahuan tentang sains, teknologi, dan bidang lainnya bagi para pengusaha akan membantu mereka menciptakan produk-produk inovatif yang hemat biaya. Kegiatan kewirausahaan dengan produk-produk inovatif ini akan membantu mengatasi tantangan perubahan lingkungan dan krisis lainnya (45). Selain itu, manajemen pengetahuan terbukti penting untuk menciptakan inovasi yang hemat biaya. Teknologi yang berubah-ubah dan kemampuan inovasi juga berperan penting dalam hubungan antara manajemen pengetahuan dan inovasi, terutama dalam mendorong inovasi yang hemat biaya (46). Hipotesis yang dirumuskan yaitu:

H8: Frugal innovation memediasi pengaruh sources of knowledge dan artificial intelligence pada green entrepreneurial sustainability.

d. Menentukan dan menyusun metode penelitian.

Penelitian ini menggunakan desain kuantitatif pendekatan *cross-sectional*. Data penelitian berupa data primer dan sekunder. Data primer dikumpulkan dengan survei menggunakan kuesioner, yang terbagi kedalam dua bagian. Bagian pertama berisi data karakteristik responden dan bagian kedua berisi item pernyataan variabel penelitian yang diukur dengan menggunakan skala Likert 5-poin. Penelitian ini menggunakan variabel independen berupa sumber pengetahuan (SoK) yang diukur dengan 10 item adaptasi (47) dan kecerdasan buatan (AI) yang diukur dengan 7 item adaptasi (15). Variabel dependen dalam penelitian ini adalah keberlanjutan wirausaha berbasis lingkungan, yang diukur melalui 8 item adaptasi (48,49). Variabel mediasi, yaitu FI, diukur menggunakan 5 item adaptasi (50) sedangkan variabel moderasi adalah sifat kepribadian (PT) yang diukur dengan 15 item adaptasi (11). Populasi penelitian adalah para mahasiswa di berbagai perguruan tinggi di Indonesia. Sampel penelitian ini adalah mahasiswa di wilayah pulau besar di Indonesia seperti Jawa, Sumatera, Kalimantan dan Sulawesi. Teknik sampling mengadopsi teknik pengambilan sampel non-probabilitas, yakni sampling insidental. Metode ini dipilih karena sampel diambil berdasarkan ketersediaan dan kemudahan akses, tanpa memperhitungkan peluang yang sama bagi setiap anggota populasi (51). Berdasarkan hasil dari pengumpulan data maka responden penelitian adalah mahasiswa di perguruan tinggi terutama di beberapa pulau besar di Indonesia yaitu Jawa, Sumatera, Kalimantan dan Sulawesi. Jumlah responden akhir yang dapat digunakan dalam penelitian ini sebanyak **314** responden (Tabel 1. Karakteristik Responden).

Tabel 1. Karakteristik Responden

No	Karakteristik	Jumlah	Persentase (%)
1	Jenis Kelamin	Perempuan	67.8
		Laki-laki	32.2
2	Usia	< 20 tahun	21.3
		20 – 25 tahun	75.5

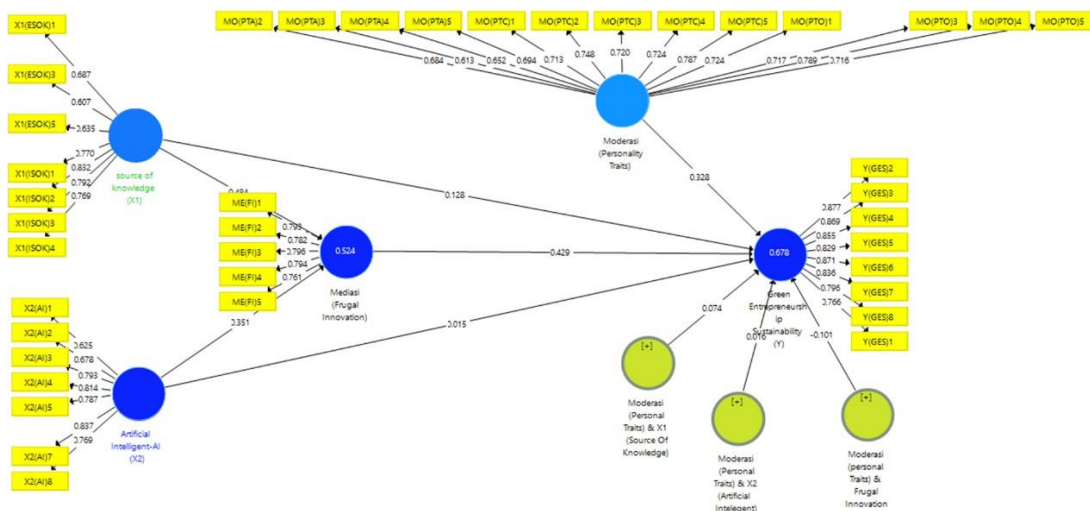
		26 – 30 tahun	3	1
		31 – 35 tahun	2	0.6
		>35 tahun	5	1.8
3	Penghasilan per bulan	< 1.000.000	172	54.8
		1.000.000 – 2.000.000	105	33.4
		2.000.000 – 3.000.000	27	8.6
		3.000.000 – 4.000.000	5	1.6
		>5.000.000	5	1.6
4	Memiliki usaha/Pernah menjalankan usaha	Ya	171	54.5
		Tidak	143	45.5
Total			314	100

(Sumber: Data primer diolah, 2024)

e. Menganalisis data penelitian.

Data yang telah terkumpul dianalisis menggunakan *Structural Equation Models* (SEM) dengan bantuan software *Smart-Partial Least Square* (SmartPLS). Tahapan uji SEM-PLS meliputi:

1. Analisis *outer model*, yang bertujuan untuk memastikan bahwa indikator yang digunakan valid dan reliabel sebagai pengukur variabel penelitian (52,53). Proses ini terdiri dari dua bagian utama:
 - a. Uji Validitas. Validitas dari model diukur dengan melihat *loading factor* atau *outer loading*. Indikator dianggap valid jika nilai *loading factor* melebihi 0.6 (52). Berdasarkan hasil analisis, indikator yang tidak valid dihapus, yaitu indikator yang memiliki nilai *loading factor* di bawah 0.6 seperti beberapa item pada variabel SoK dan AI. Setelah indikator yang tidak valid dihapus, hasil akhir menunjukkan bahwa semua item yang tersisa memenuhi syarat validitas dengan nilai *loading factor* di atas 0.6 (Gambar 2. Struktur Model Penelitian).



Gambar 2. Hasil Outer Model
(Sumber: Data primer diolah, 2024)

- b. Uji Reliabilitas. Reliabilitas diuji dengan menggunakan *Composite Reliability* (CR) yang harus lebih dari 0.7 dan *Average Variance Extracted* (AVE) yang harus melebihi 0.5 (52). Hasil analisis menunjukkan bahwa semua variabel penelitian, baik variabel independen, mediasi, maupun moderasi, memiliki nilai CR di atas 0.7 dan AVE lebih dari 0.5 yang berarti bahwa pengukuran untuk setiap variabel dapat diandalkan dan memiliki reliabilitas yang baik (Tabel 2. Hasil Uji Nilai CR dan AVE).

Tabel 2. Hasil Uji Nilai CR dan AVE

Variabel	CR	AVE
AI	0.905	0.579
GES	0.950	0.703
FI	0.889	0.617
PT → SoK	1.000	1.000

PT → AI	1.000	1.000
PT	0.931	0.512
PT → FI	1.000	1.000
SoK	0.889	0.535

Sumber: Data primer diolah (2024)

2. Analisis *inner model*. Analisis ini bertujuan untuk mengevaluasi kekuatan prediksi dan akurasi model struktural (56,57). Beberapa parameter yang digunakan dalam analisis inner model adalah:
- R-Square* (R^2). Nilai R^2 mengindikasikan seberapa besar variasi variabel dependen yang dapat dijelaskan oleh variabel independen (52). Berdasarkan hasil analisis, model menunjukkan nilai R^2 sebesar 0.67 yang berarti variabel-variabel seperti KS, AI, FI menjelaskan 67% dari variasi dalam GES, yang merupakan pengaruh kuat (Tabel 3. Hasil Uji Nilai R-Square (R^2)).

Tabel 3. Hasil Uji Nilai R-Square (R^2)

Variabel	R Square	R Square Adjusted
GES	0.678	0.670
FI	0.524	0.521

Sumber: Data primer diolah (2024)

- Q-Square* (Q^2). Nilai ini digunakan untuk mengukur kemampuan prediktif model. Nilai uji *Q-Square* (Q^2) > 0 artinya variabel dan data bisa memprediksi model dengan baik (52). Nilai Q^2 yang diperoleh sebesar 0.47 menunjukkan bahwa model memiliki relevansi prediktif yang baik (Tabel 4. Hasil Uji Nilai *Q-Square* (Q^2)).

Tabel 4. Hasil Uji Nilai Q-Square (Q^2)

Variabel	Q^2
GES	0.470
FI	0.312

Sumber: Data primer diolah (2024)

- Standardized Root Mean Square Residual* (SRMR): Nilai SRMR yang kurang dari 0.08 dianggap sebagai indikator model yang baik (52). Hasil SRMR sebesar 0.063 menunjukkan bahwa model fit atau sesuai dengan data empiris yang ada (Tabel 5. Hasil Uji Nilai SRMR (Model Fit)).

Tabel 5. Hasil Uji Nilai SRMR (Model Fit)

Kriteria	Saturated Model	Estimated Model
SRMR	0.057	0.063

Sumber: Data primer diolah (2024)

3. Pengujian hipotesis. Pengujian hipotesis dilakukan dengan menggunakan nilai t-statistic dan p-value. Hipotesis diterima jika nilai t-statistik > 1.96 atau p-value < 0.05. Berikut adalah hasil pengujian hipotesis (Tabel 6. Hasil Uji Hipotesis):
- H1: SoK berpengaruh positif pada FI, hasilnya hipotesis didukung.
 - H2: SoK berpengaruh positif pada GES, hasil menyatakan hipotesis didukung.
 - H3: AI berpengaruh positif pada FI, hasil menunjukkan bahwa hipotesis didukung.
 - H4: AI berpengaruh positif pada GES, hasil memberikan dukungan pada hipotesis.
 - H5: FI berpengaruh positif pada GES, hasil menyatakan hipotesis didukung.
 - H6: PT berpengaruh positif pada GES, berdasarkan hasil maka hipotesis didukung.
 - H7: PT memoderasi hubungan antara KS, AI, dan FI terhadap GES, hasil menunjukkan hipotesis tidak didukung.
 - H8: FI memediasi pengaruh KS dan AI terhadap GES, hasil menyatakan hipotesis didukung dengan mediasi parsial.

Tabel 6. Hasil Uji Hipotesis

Variabel	Original Sampel (O)	Standar Deviation (STDEV)	t-statistik	p-value
AI → GES	0.165	0.047	3.538	0.000
AI → FI	0.315	0.0044	7.966	0.000
FI → GES	0.429	0.054	7.901	0.000

PT & SoK → GES	0.074	0.052	1.433	0.152
PT & AI → GES	0.016	0.041	0.395	0.693
PT → GES	0.328	0.053	6.188	0.000
PT & FI → GES	-0.101	0.049	2.064	0.039
SoK → GES	0.336	0.060	5.592	0.000
SoK → FI	0.484	0.052	9.230	0.000

Sumber: Data Primer diolah (2024)

f. Pembahasan hasil penelitian

Penelitian ini meneliti hubungan antara Sumber Pengetahuan (SoK), *Artificial Intelligence* (AI), *Frugal Innovation* (FI), dan Kepribadian (*Personality Traits*/PT) terhadap Keberlanjutan Wirausaha Berbasis Lingkungan (*Green Entrepreneurial Sustainability*/GES). Hasil penelitian menunjukkan adanya hubungan positif antara variabel-variabel ini, dengan beberapa temuan yang penting untuk dipahami lebih mendalam.

1. Pengaruh SoK terhadap FI dan GES. Hasil analisis menunjukkan bahwa SoK berpengaruh signifikan terhadap FI dan GES. Pengetahuan yang luas, baik dari internal maupun eksternal, sangat berperan dalam mendorong inovasi hemat, yang pada akhirnya meningkatkan keberlanjutan wirausaha. Hal ini sesuai dengan penelitian terdahulu yang menunjukkan bahwa jaringan sosial yang kuat membantu wirausahawan dalam memperoleh pengetahuan baru yang relevan, yang dapat diterapkan untuk menciptakan solusi hemat biaya dan ramah lingkungan (15–18). Pengetahuan yang dibagikan dalam organisasi atau sebuah usaha juga memiliki peran penting dalam mewujudkan FI (54).
2. Peran AI dalam FI dan GES, teknologi AI memiliki peran penting dalam meningkatkan inovasi dan keberlanjutan wirausaha. Hasil penelitian ini mendukung pandangan bahwa AI dapat membantu UKM mengatasi keterbatasan sumber daya melalui solusi yang lebih efisien dan inovatif. AI juga mendukung terciptanya inovasi yang hemat biaya, yang merupakan fondasi dari model bisnis berkelanjutan di sektor wirausaha. Teknologi AI memungkinkan wirausahawan untuk memanfaatkan data dalam skala besar untuk pengambilan keputusan yang lebih baik, sehingga mendukung efisiensi operasional dan keberlanjutan lingkungan (19–24,28–30,32–34).
3. FI sebagai mediator. Salah satu temuan menarik dari penelitian ini adalah peran FI sebagai variabel mediasi. Hasil penelitian menunjukkan bahwa FI secara parsial memediasi hubungan antara SoK dan AI terhadap keberlanjutan wirausaha. Ini berarti bahwa FI memainkan peran kunci dalam menghubungkan pengetahuan dan teknologi dengan keberlanjutan wirausaha berbasis lingkungan (42,43). Dengan kata lain, wirausahawan yang menerapkan inovasi hemat lebih mungkin mencapai keberlanjutan, terutama jika mereka dapat memanfaatkan sumber pengetahuan yang relevan dan teknologi AI dengan baik.
4. Peran ciri kepribadian pada keberlanjutan wirausaha. Sifat kepribadian tertentu seperti keterbukaan terhadap pengalaman baru dan ekstroverti berpengaruh positif pada keberlanjutan wirausaha berbasis lingkungan. Pendiri usaha yang memiliki kepribadian terbuka cenderung lebih inovatif dan siap mengadopsi solusi ramah lingkungan dalam bisnis mereka. Selain itu, temuan studi sebelumnya menunjukkan karakteristik individu seperti jenis kelamin, usia, latar belakang pendidikan, dan latar belakang profesional pengusaha semuanya memiliki efek signifikan pada kewirausahaan berbasis lingkungan (55). Namun, variabel kepribadian tidak memoderasi secara signifikan hubungan antara AI, KS, dan FI terhadap keberlanjutan, yang menunjukkan bahwa kepribadian mungkin berperan lebih besar dalam pengambilan keputusan strategis individu daripada dalam memoderasi efek pengetahuan dan teknologi (44–46).

g. Kesimpulan dari hasil penelitian.

Penelitian ini berhasil membuktikan bahwa KS, AI, dan FI memiliki peran penting dalam mendukung GES. FI berfungsi sebagai mediator yang kuat, menghubungkan pengetahuan dan teknologi dengan keberlanjutan. Sementara itu, ciri kepribadian meskipun berpengaruh terhadap keputusan untuk memulai usaha ramah lingkungan, tidak memoderasi hubungan antara pengetahuan, AI, dan inovasi hemat.

h. Implikasi praktis dari hasil penelitian.

1. Peningkatan akses pengetahuan: Pemerintah dan lembaga pendidikan perlu menyediakan akses yang lebih luas terhadap sumber pengetahuan untuk mendorong inovasi di sektor wirausaha berbasis lingkungan.
2. Pengembangan kapasitas teknologi: Pelatihan dan pengembangan keterampilan dalam penggunaan AI di kalangan wirausahawan, terutama di sektor UMKM, sangat diperlukan untuk memastikan adopsi teknologi yang lebih luas.
3. Dukungan kebijakan: Kebijakan yang mendorong inovasi hemat dan ramah lingkungan harus ditingkatkan, terutama dalam hal insentif untuk adopsi teknologi berkelanjutan.

i. Keterbatasan penelitian.



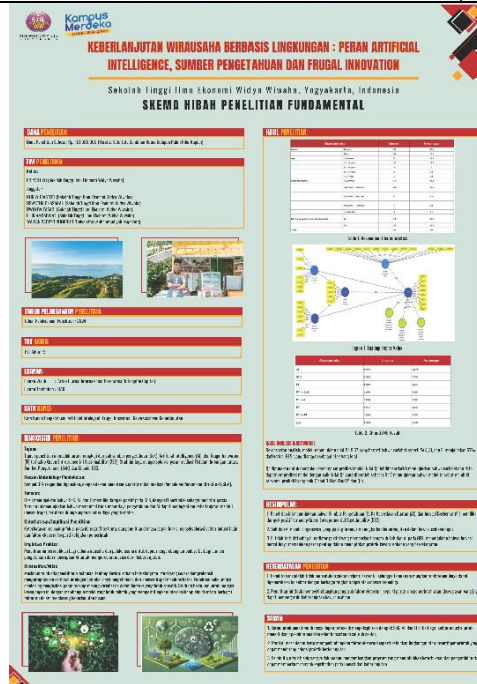

1. Keterbatasan data dan sampel. Penelitian ini menggunakan sampel mahasiswa dari beberapa perguruan tinggi di Indonesia sebagai responden utama. Meskipun ini memberikan wawasan berharga, sampel ini mungkin tidak sepenuhnya mewakili populasi wirausaha secara keseluruhan. Penggunaan sampel yang lebih beragam, termasuk wirausahawan dari berbagai latar belakang industri dan skala bisnis, dapat memberikan hasil yang lebih umum dan relevan untuk seluruh ekosistem wirausaha.
 2. Keterbatasan dalam pengukuran kepribadian. Pengukuran kepribadian dalam penelitian ini dilakukan dengan skala yang terbatas, dengan adaptasi dari beberapa instrumen yang ada. Hal ini mungkin tidak mencakup semua dimensi penting dari kepribadian yang relevan dengan kewirausahaan berbasis lingkungan. Penelitian lebih lanjut perlu mengembangkan alat pengukuran kepribadian yang lebih komprehensif dan spesifik untuk kewirausahaan.
 3. Keterbatasan penggunaan variabel AI. Meskipun penelitian ini menemukan hubungan antara AI dan FI, adopsi AI di kalangan wirausahawan kecil dan menengah masih terbatas. Banyak UKM di Indonesia yang mungkin belum memiliki akses penuh atau sumber daya untuk mengintegrasikan AI dalam operasi mereka, yang dapat membatasi generalisasi hasil penelitian ini pada konteks yang lebih luas.
 4. Keterbatasan dalam pengujian moderasi kepribadian. Meskipun kepribadian diperhitungkan sebagai variabel moderasi, hasil penelitian menunjukkan bahwa peran moderasi kepribadian tidak signifikan dalam hubungan antara sumber pengetahuan, AI, dan inovasi hemat terhadap keberlanjutan. Keterbatasan ini menunjukkan bahwa ada kemungkinan variabel moderasi lain yang lebih relevan yang belum teridentifikasi dan diuji dalam penelitian ini.
 5. Keterbatasan temporal. Penelitian ini menggunakan pendekatan *cross-sectional* yang mengumpulkan data pada satu titik waktu tertentu. Pendekatan ini tidak memberikan gambaran tentang bagaimana hubungan antara variabel-variabel ini berkembang seiring waktu. Studi longitudinal yang melacak perubahan perilaku wirausaha dan pengadopsian teknologi berkelanjutan dalam jangka waktu yang lebih panjang akan lebih memberikan pemahaman mendalam mengenai dinamika yang ada
- j. Saran penelitian berikutnya.
1. Penggunaan sampel yang lebih beragam. Penelitian di masa mendatang disarankan untuk menggunakan sampel yang lebih luas dan beragam, mencakup wirausahawan dari berbagai sektor dan tingkat pengalaman untuk meningkatkan generalisasi temuan.
 2. Pengembangan alat ukur kepribadian yang lebih spesifik. Perlu dikembangkan alat ukur kepribadian yang lebih spesifik dan sesuai untuk konteks kewirausahaan berbasis lingkungan, guna memahami dampak yang lebih mendalam dari berbagai dimensi kepribadian terhadap keberlanjutan usaha.
 3. Pengujian variabel moderasi lain. Penelitian selanjutnya dapat mengidentifikasi dan menguji variabel moderasi lain yang mungkin lebih relevan, seperti inovasi model bisnis atau kesiapan teknologi, yang dapat memperkuat hubungan antara AI, FI, dan keberlanjutan wirausaha.
 4. Studi longitudinal. Studi yang dilakukan dalam jangka panjang untuk memantau perkembangan adopsi teknologi AI dan perubahan dalam perilaku kewirausahaan akan sangat bermanfaat untuk memahami dampak berkelanjutan dari inovasi hemat.


D. STATUS LUARAN: Tuliskan jenis, identitas dan status ketercapaian setiap luaran wajib dan luaran tambahan (jika ada) yang dijanjikan. Jenis luaran dapat berupa publikasi, perolehan kekayaan intelektual, atau luaran lainnya yang telah dijanjikan pada proposal. Uraian status luaran harus didukung dengan bukti kemajuan ketercapaian luaran sesuai dengan luaran yang dijanjikan. Lengkapi isian jenis luaran yang dijanjikan serta mengunggah bukti dokumen ketercapaian luaran melalui BIMA.

Berikut adalah status luaran dari penelitian ini (Tabel 7. Status Luaran).

Tabel 7. Status Luaran

No	Jenis Luaran	Identitas Luaran (Judul dll)	Status Capaian	Bukti Capaian	Catatan
1	Publikasi ilmiah	a. Judul Artikel: <i>Environmental Entrepreneurship Sustainability: Exploring AI, Knowledge, and Frugal Innovation.</i> b. Nama Jurnal:	Submitted	https://www.intangiblecapital.org/index.php/ic/index	Jurnal Internasional bereputasi. https://www.scimagojr.com/journalsearch.php?q=17700156749&tip=sid&cl

		Intangible Capital.			ean=0
			In Review	https://www.intangiblecapital.org/index.php/index 	Jurnal Internasional bereputasi. https://www.scimagojr.com/journalsearch.php?q=17700156749&tip=sid&cl ean=0
2	Poster	Poster skema hibah penelitian fundamental dengan judul: Keberlanjutan Wirausaha berbasis Lingkungan: Peran <i>Artificial Intelligence</i> , Sumber Pengetahuan, dan <i>Frugal Innovation</i>	Selesai		
3	Video	Video skema hibah penelitian fundamental dengan judul: Keberlanjutan Wirausaha berbasis Lingkungan: Peran <i>Artificial Intelligence</i> , Sumber Pengetahuan, dan <i>Frugal Innovation</i>	Selesai		https://drive.google.com/file/d/IFAmkCiy0YGMNSUSLsWvHzImucJT4r9hx/view?usp=sharing

4	HKI	Judul Cipta: Keberlanjutan Wirausaha Berbasis Lingkungan: Peran <i>Artificial Intelligence</i> , Sumber Pengetahuan dan <i>Frugal Innovation</i>	Selesai		Sertifikat HKI Nomor dan tanggal permohonan: EC00202425 7594, 20 Desember 2024
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E. PERAN MITRA: Tuliskan realisasi kerjasama dan kontribusi Mitra baik *in-kind* maupun *in-cash* serta mengunggah bukti dokumen pendukung sesuai dengan kondisi yang sebenarnya. Bukti dokumen realisasi kerjasama dengan Mitra dapat diunggah melalui BIMA.

Catatan:

Bagian ini wajib diisi untuk penelitian terapan, untuk penelitian dasar (Fundamental, Pascasarjana, PKDN, Dosen Pemula) boleh mengisi bagian ini (tidak wajib) jika melibatkan mitra dalam pelaksanaan penelitiannya

Realisasi kerjasama dengan mitra yaitu Universitas Muhammadiyah Magelang:

- Bentuk Kerjasama: Mitra berperan dalam memberikan dukungan data dan akses ke responden untuk pengumpulan informasi.
- Kontribusi In-kind: Mitra menyediakan fasilitas berupa akses jaringan penyebaran kuesioner, serta sebagai tenaga ahli untuk konsultasi dalam bidang yang relevan dengan penelitian.
- Kontribusi In-cash: Mitra berkontribusi finansial untuk biaya publikasi penelitian sebesar Rp. 1.800.000. (bukti kontribusi ada di lampiran dari laporan ini di halaman terakhir setelah daftar pustaka).

F. KENDALA PELAKSANAAN PENELITIAN: Tuliskan kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan, termasuk penjelasan jika pelaksanaan penelitian dan luaran penelitian tidak sesuai dengan yang direncanakan atau dijanjikan.

Hambatan dalam pelaksanaan penelitian yaitu:

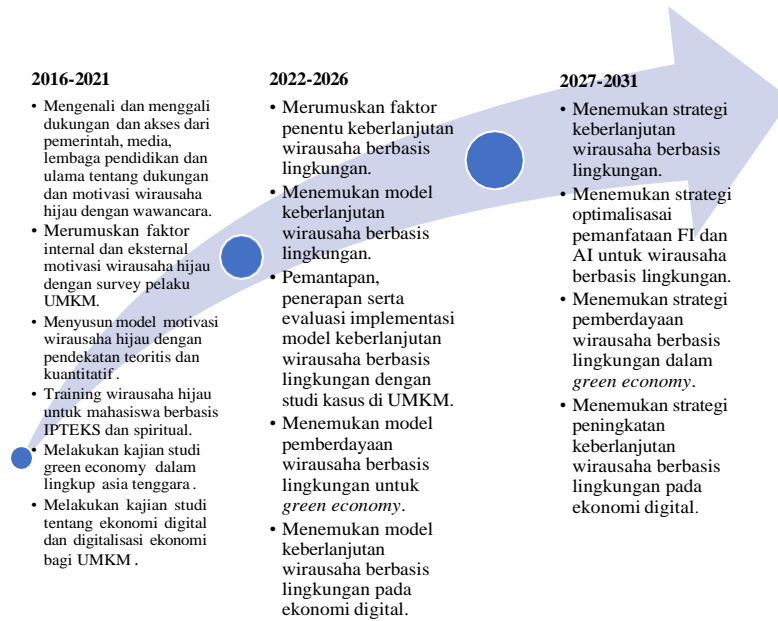
- Hambatan dalam pengumpulan data.
Pengumpulan data dari responden, terutama mahasiswa aktif di berbagai kampus di Indonesia, seringkali menghadapi tantangan. Misalnya, keterbatasan akses terhadap responden, jadwal yang tidak sesuai, atau kurangnya partisipasi sehingga perlu penambahan waktu untuk pengumpulan data. Hal ini juga menyebabkan keterlambatan dalam proses analisis dan mempengaruhi timeline penelitian yang direncanakan. Beberapa responden juga memberikan data yang tidak lengkap, sehingga data harus divalidasi dan diolah ulang.
- Hambatan dalam mencapai luaran.
Proses review jurnal yang panjang menyebabkan publikasi artikel ilmiah mengalami penundaan. Selain itu, tingginya biaya publikasi untuk jurnal bereputasi dan terindeks internasional mengakibatkan perlunya penambahan waktu pencarian dan pemilihan jurnal yang dapat diakomodir anggaran penelitian. Anggaran penelitian yang terbatas mengakibatkan tim peneliti hanya dapat menggunakan sampel terbatas, sehingga generalisasi hasil penelitian mungkin dapat berdampak.

G. RENCANA TAHAPAN SELANJUTNYA: Tuliskan dan uraikan rencana penelitian selanjutnya

berdasarkan indikator luaran yang telah dicapai, rencana realisasi luaran wajib yang dijanjikan dan tambahan (jika ada) di tahun berikutnya serta *roadmap* penelitian keseluruhan. Pada bagian ini diperbolehkan untuk melengkapi penjelasan dari setiap tahapan dalam metoda yang akan direncanakan termasuk jadwal berkaitan dengan strategi untuk mencapai luaran seperti yang telah dijanjikan dalam proposal. Jika diperlukan, penjelasan dapat juga dilengkapi dengan gambar, tabel, diagram, serta pustaka yang relevan. Jika laporan kemajuan merupakan laporan pelaksanaan tahun terakhir, pada bagian ini dapat dituliskan rencana penyelesaian target yang belum tercapai.

Mengacu pada evaluasi terhadap hasil penelitian tahap sebelumnya, berikut adalah rancangan penelitian lanjutan yang bertujuan untuk mencapai seluruh indikator keberhasilan yang telah ditetapkan dalam proposal penelitian dan berdasarkan *roadmap* penelitian (Gambar 3. *Roadmap* Penelitian).

1. Penelitian lanjutan berdasarkan hasil penelitian dan capaian luaran.
Berdasarkan luaran yang telah dicapai, penelitian selanjutnya akan difokuskan pada pengembangan dan pemanfaatan hasil penelitian untuk lebih memperdalam dan memperluas model yang telah dirumuskan. Beberapa fokus utama yang akan dikembangkan meliputi:
 - a. Model keberlanjutan wirausaha berbasis lingkungan yang telah dirumuskan akan divalidasi dengan uji coba dalam konteks usaha kecil dan menengah. Tujuannya untuk memperoleh pemahaman yang lebih komprehensif mengenai faktor-faktor yang mendukung atau menghambat penerapan model ini dalam skala yang lebih besar sekaligus membuka peluang untuk pengembangan model yang lebih luas dan berkelanjutan.
 - b. Evaluasi implementasi dari model keberlanjutan wirausaha berbasis lingkungan dalam lingkungan wirausaha. Evaluasi implementasi menggunakan analisis lapangan untuk melihat bagaimana model keberlanjutan wirausaha berbasis lingkungan dapat diadopsi oleh berbagai pelaku usaha.
2. Rencana realisasi luaran wajib.
Penelitian akan difokuskan untuk menghasilkan artikel ilmiah yang siap dipublikasikan di jurnal terindeks internasional misalnya Scopus atau terindeks nasional misalnya Sinta 2 atau 3. Pada tahun berikutnya, ditargetkan minimal satu artikel dapat terpublikasi yang berisi hasil temuan utama dari penelitian ini.
3. *Roadmap* penelitian keseluruhan.
 - a. Tahun 1 (saat ini):
 1. Pengumpulan data awal dan pengembangan model dasar AI, sumber pengetahuan, dan *frugal innovation* untuk keberlanjutan wirausaha berbasis lingkungan.
 2. Uji validitas dan reliabilitas model melalui *Structural Equation Model* (SEM) serta analisis data.
 3. Realisasi luaran wajib dalam bentuk publikasi artikel ilmiah.
 - b. Tahun 2:
Pemantapan, penerapan serta evaluasi implementasi model keberlanjutan wirausaha berbasis lingkungan dengan studi kasus di UMKM dan pengembangan publikasi ilmiah.
 - c. Tahun 3:
Menemukan model pemberdayaan wirausaha berbasis lingkungan untuk mendukung *green economy*.
 - d. Tahun 4:
Menemukan model keberlanjutan wirausaha berbasis lingkungan pada ekonomi digital.
 - e. Tahun 5 hingga tahun 7:
Menemukan strategi untuk keberlanjutan wirausaha berbasis lingkungan, optimalisasi penggunaan FI dan AI, pemberdayaan untuk *green economy* dan keberlanjutan wirausaha berbasis lingkungan pada ekonomi digital.



Gambar 3. Roadmap Penelitian

H. DAFTAR PUSTAKA: Penyusunan Daftar Pustaka berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan akhir yang dicantumkan dalam Daftar Pustaka.

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**SURAT PERNYATAAN
KONTRIBUSI MITRA PELAKSANAAN PENELITIAN
STIE WIDYA WIWAHA YOGYAKARTA**

Yang bertanda tangan di bawah ini:

Nama : Dr. Wawan Sadtyo Nugroho, MSi, Ak, CA
Jabatan : Lektor
Instansi/Lembaga : Universitas Muhammadiyah Magelang
No Telepon/HP : +62857-1104-5758
Alamat : Jl. Mayjend. Bambang Soegeng, Mertoyudan, Magelang
56172

dengan ini menyatakan bersedia menjadi mitra terhadap penelitian:

Nama : Dr. Priyastiwi, SE, MSi, Ak, CA
NIDN : 0522106801
Judul Proposal : Keberlanjutan Bisnis Wirausaha Hijau: Peran *Artificial Intelligence*, Sumber Pengetahuan dan *Frugal Innovation*.
Bentuk Dukungan : Mitra Penelitian

Dan saya menyatakan bahwa saya telah ikut sebagai mitra penelitian dengan kontribusi sebagai berikut:

1. Dalam mengumpulkan data melakukan wawancara kepada responden dan membagi kuisioner.
2. Berkontribusi dalam penulisan artikel publikasi.
3. Membuat poster.
4. Memberikan dana *in cash* untuk tambahan biaya publikasi sebesar Rp1.800.000,00.

Yogyakarta, 16 Desember 2024



Dr. Wawan Sadtyo Nugroho, MSi, Ak, CA



Transfer Rupiah

Transfer Berhasil!

28 Okt 2024 · 13:39:01 WIB

Penerima

PRIYASTIWI

Bank Negara Indonesia - 0030424037

Detail Transaksi

Nominal Transfer Rp 1.800.000

Metode Transfer BI Fast

No. Referensi 20241028BMRIIDJA01
BI Fast 000224433459

Tujuan Transaksi Transfer Kekayaan

Biaya Transaksi Rp 2.500

Total Transaksi Rp 1.802.500

Rekening Sumber

DODDY BAGUS JATMIKO

Bank Mandiri 0100

**SURAT PERNYATAAN
KONTRIBUSI MITRA PELAKSANAAN PENELITIAN
STIE WIDYA WIWAHA YOGYAKARTA**

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dengan ini menyatakan bersedia menjadi mitra terhadap penelitian:

Nama : Dr. Priyastiwi, SE, MSi, Ak, CA
NIDN : 0522106801
Judul Proposal : Keberlanjutan Bisnis Wirausaha Hijau: Peran *Artificial Intelligence*, Sumber Pengetahuan dan *Frugal Innovation*.
Bentuk Dukungan : Mitra Penelitian

Dan saya menyatakan bahwa saya telah ikut sebagai mitra penelitian dengan kontribusi sebagai berikut:

1. Dalam mengumpulkan data melakukan wawancara kepada responden dan membagi kuisisioner.
2. Berkontribusi dalam penulisan artikel publikasi.
3. Membuat poster.
4. Memberikan dana *in cash* untuk tambahan biaya publikasi sebesar Rp1.800.000,00.

Yogyakarta, 16 Desember 2024



Dr. Wawan Sadtyo Nugroho, MSi, Ak, CA



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Detail Transaksi

Nominal Transfer Rp 1.800.000

Metode Transfer BI Fast

No. Referensi 20241028BMRIIDJA01
BI Fast 000224433459

Tujuan Transaksi Transfer Kekayaan

Biaya Transaksi Rp 2.500

Total Transaksi Rp 1.802.500

Rekening Sumber

DODDY BAGUS JATMIKO

Bank Mandiri 0100

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SURAT PENCATATAN CIPTAAN

Dalam rangka perlindungan ciptaan di bidang ilmu pengetahuan, seni dan sastra berdasarkan Undang-Undang Nomor 28 Tahun 2014 tentang Hak Cipta, dengan ini menerangkan:

Nomor dan tanggal permohonan : EC002024257594, 20 Desember 2024

Pencipta

Nama : **Priyastiwi, Nur Widiastuti dkk**

Alamat : Bintaran Kidul MG II/108, RT/RW 007/002, Wirogunan, Mergangsan, Yogyakarta, DI Yogyakarta, 55151

Kewarganegaraan : Indonesia

Pemegang Hak Cipta

Nama : **STIE Widya Wiwaha**

Alamat : Jl. Lowanu UH VI / 20, Sorosutan, Umbulharjo, Yogyakarta, Di Yogyakarta 55162

Kewarganegaraan : Indonesia

Jenis Ciptaan : **Poster**

Judul Ciptaan : **KEBERLANJUTAN WIRUSAHA BERBASIS LINGKUNGAN:
PERAN ARTIFICIAL INTELLIGENCE, SUMBER
PENGETAHUAN DAN FRUGAL INNOVATION**

Tanggal dan tempat diumumkan untuk pertama kali : 20 Desember 2024, di Yogyakarta
di wilayah Indonesia atau di luar wilayah Indonesia

Jangka waktu perlindungan : Berlaku selama hidup Pencipta dan terus berlangsung selama 70 (tujuh puluh) tahun setelah Pencipta meninggal dunia, terhitung mulai tanggal 1 Januari tahun berikutnya.

Nomor pencatatan : 000830026

adalah benar berdasarkan keterangan yang diberikan oleh Pemohon.

Surat Pencatatan Hak Cipta atau produk Hak terkait ini sesuai dengan Pasal 72 Undang-Undang Nomor 28 Tahun 2014 tentang Hak Cipta.



a.n. MENTERI HUKUM
DIREKTUR JENDERAL KEKAYAAN INTELEKTUAL
u.b

Direktur Hak Cipta dan Desain Industri

Agung Damarsasongko,SH.,MH.
NIP. 196912261994031001

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LAMPIRAN PENCIPTA

No	Nama	Alamat
1	Priyastiwi	Bintaran Kidul MG II/108, RT/RW 007/002, Wirogunan, Mergangsan, Yogyakarta
2	Nur Widiastuti	Perum Pelem Sewu Blok N.1 RT/RW 010/000, Panggungharjo, Bantul, Bantul
3	Uswatun Chasanah	Sindurejan WB 3/92 RT/RW 045/009, Patangpuluhan, Wirobrajan, Yogyakarta
4	Dwi Novitasari	Morangan RT/RW 002/002, Karangnom, Klaten Utara, Karangnom, Klaten
5	Lilik Ambarwati	Jaranan RT.002/RW.000, Panggungharjo, Sewon, Bantul, Bantul
6	Wawan Sadtyo Nugroho	Drojogan RT/RW 006/003, Bumirejo, Mungkid, Mungkid, Magelang



KEBERLANJUTAN WIRAUSAHA BERBASIS LINGKUNGAN : PERAN ARTIFICIAL INTELLIGENCE, SUMBER PENGETAHUAN DAN FRUGAL INNOVATION

Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha, Yogyakarta, Indonesia
SKEMA HIBAH PENELITIAN FUNDAMENTAL

DANA PENELITIAN:

Dana Penelitian Sebesar Rp. 101.980.000 (Seratus Satu Juta Sembilan Ratus Delapan Puluh Ribu Rupiah)

TIM PENELITIAN:

Ketua :

PRIYASTIWI (Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha)

Anggota :

NUR WIDIASTUTI (Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha)

USWATUN CHASANAH (Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha)

DWI NOVITASARI (Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha)

LILIK AMBARWATI (Sekolah Tinggi Ilmu Ekonomi Widya Wiwaha)

WAWAN SADTYO NUGROHO (Universitas Muhammadiyah Magelang)



TAHUN PELAKSANAAN PENELITIAN:

Tahun Pelaksanaan Penelitian : 2024

TKT AKHIR:

TKT Akhir : 3

LUARAN:

Luaran Wajib : Artikel Jurnal Internasional Bereputasi (Intangible Capital)

Luaran Tambahan : HAKI

KATA KUNCI:

Kata Kunci: Pengetahuan, Artificial Intelegent, Frugal Innovation, Kewirausahaan Keberlanjutan

RINGKASAN PENELITIAN:

Tujuan:

Tujuan penelitian ini adalah untuk mengkaji dampak sumber pengetahuan (SoK), Artificial Intelligence (AI), dan Frugal Innovation (FI) terhadap Green Entrepreneurial Sustainability (GES). Studi ini juga mengeksplorasi peran mediasi FI dalam hubungan antara Sumber Pengetahuan (SoK) dan AI pada GES.

Desain/Metodologi/Pendekatan:

Sampel 314 responden digunakan, dengan desain penelitian kuantitatif dan analisis Pemodelan Persamaan Struktural (SEM).

Temuan:

Hasil menunjukkan bahwa SoK, AI, dan FI memiliki dampak positif pada GES, dengan FI bertindak sebagai mediator parsial. Temuan ini menunjukkan bahwa memanfaatkan sumber daya pengetahuan dan AI dapat meningkatkan keberlanjutan melalui inovasi frugal, terutama di lingkungan sumber daya yang terbatas.

Keterbatasan/Implikasi Penelitian:

Keterbatasan mencakup fokus pada demografi tertentu, dan penelitian di masa depan harus mengeksplorasi sektor industri lain dan faktor eksternal seperti kebijakan pemerintah.

Implikasi Praktis:

Penelitian ini berimplikasi bagi calon wirausaha dan pelaku usaha untuk dapat mengembangkan budaya berbagi sumber pengetahuan dan menerapkan AI untuk mempercepat inovasi demi keberlanjutan.

Orisinalitas/Nilai:

Meskipun telah ada penelitian substansial tentang kewirausahaan berkelanjutan, studi yang secara komprehensif mengintegrasikan artificial intelegent, sumber daya pengetahuan, dan inovasi frugal masih terbatas. Penelitian sebelumnya cenderung mengisolasi peran masing-masing variabel ini dalam konteks yang lebih spesifik. Studi ini bertujuan untuk mengisi kesenjangan ini dengan membangun model yang lebih holistik yang memperhitungkan interaksi kompleks di antara berbagai faktor ini dalam mendorong keberlanjutan bisnis.



HASIL PENELITIAN:

Characteristics	Amount	Percentage	
Gender	Women	213	67.8
	Man	101	32.2
Age	< 20 years	67	21.3
	20 - 25 years	237	75.5
	26 - 30 years	3	1
	31 - 35 years	2	0.6
	> 35 years	5	1.6
Monthly income	< 1.000.000	172	54.8
	1.000.000 - 2.000.000	105	33.4
	2.000.000 - 3.000.000	27	8.6
	3.000.000 - 4.000.000	5	1.6
	> 5.000.000	5	1.6
Have a business/Have run a business	Yes	171	54.5
	No	143	45.5
Total		314	100

Table 1. Respondent Characteristics

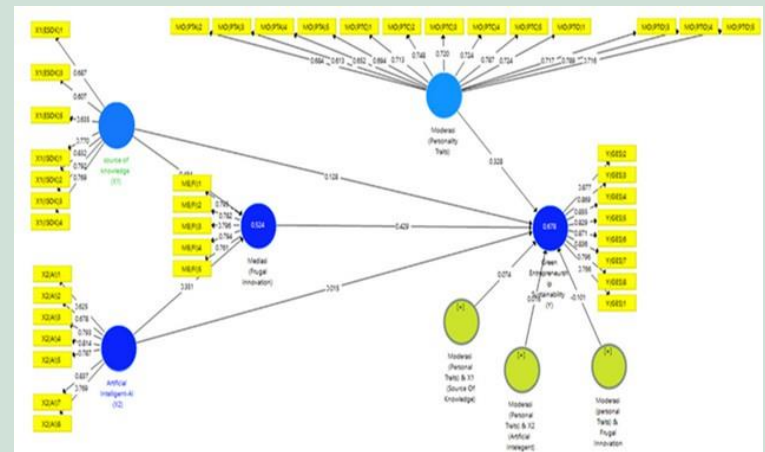


Figure 1. Loading Factor Value

Characteristics	Amount	Percentage
AI	0.905	0.579
GES	0.950	0.703
FI	0.889	0.617
PT → SoK	1.000	1.000
PT → AI	1.000	1.000
PT	0.931	0.512
PT → FI	1.000	1.000
SoK	0.889	0.535

Table 2. CR and AVE Result

HASIL ANALISIS INNER MODEL

Berdasarkan analisis, model menunjukkan nilai R² 0,67, yang berarti bahwa variabel seperti SoK, AI, dan FI menjelaskan 67% dari variasi GES, yang dianggap sebagai efek yang kuat.

Q² digunakan untuk mengukur kemampuan prediksi model. Nilai Q² lebihbesardari 0 menunjukkan bahwa variabel dan data dapatmemprediksi model dengan baik. Nilai Q² yang diperoleh sebesar 0,47 menunjukkan bahwa model tersebut memiliki relevansi prediktif yang baik (Tabel 3. HasilTes R² dan Q²).

KESIMPULAN:

1. Penelitian ini menunjukkan bahwa Sumber Pengetahuan (SoK), Kecerdasan Buatan (AI), dan Inovasi Berhemat (FI) memiliki dampak positif terhadap Green Entrepreneurial Sustainability (GES).
2. SoK dan AI mendorong inovasi, yang pada gilirannya meningkatkan keberlanjutan dalam kewirausahaan hijau.
3. FI telah terbukti sebagai mediator parsial yang memperkuat pengaruh SoK dan AI pada GES, menunjukkan bahwa inovasi hemat biaya memainkan peran penting dalam menciptakan praktik kewirausahaan yang berkelanjutan.

KETERBATASAN PENELITIAN:

1. Penelitian ini adalah tidak menentukan sektor industri tertentu, sehingga temuan ini mungkin tidak sepenuhnya dapat digeneralisasi ke sektor dengan berbagai tingkat adopsi atau inovasi teknologi.
2. Penelitian ini tidak mempertimbangkan pengaruh faktor eksternal, seperti peraturan pemerintah atau akses pasar, yang juga dapat memengaruhi keberlanjutan kewirausahaan.

SARAN:

1. Saran untuk penelitian di masa depan termasuk mengeksplorasi dampak SoK, AI, dan FI di berbagai sektor industri untuk menentukan apakah temuan tersebut konsisten di seluruh sektor.
2. Studi di masa depan harus mempertimbangkan faktor eksternal seperti kebijakan lingkungan atau insentif pemerintah yang dapat mendorong adopsi praktik berkelanjutan.
3. Selain itu, untuk bisnis yang sudah mapan, mengembangkan program yang menumbuhkan keterbukaan dan pengambilan risiko dapat memperkuat dampak kepribadian pada inovasi dan keberlanjutan.

1 **ENVIRONMENTAL ENTREPRENEURSHIP SUSTAINABILITY: EXPLORING**
2 **ARTIFICIAL INTELLIGENCE, KNOWLEDGE AND FRUGAL INNOVATION**

3

4 **Purpose:** This study aims to investigate the impact of Knowledge Source (KS), Artificial Intelligence
5 (AI), and Frugal Innovation (FI) on the sustainability of entrepreneurship. Additionally, the research
6 examines the mediating role of FI in the relationship between KS and AI in influencing entrepreneurial
7 sustainability.

8 **Design/methodology/approach:** A sample of 314 respondents was used, with a quantitative cross-
9 sectional design and Structural Equation Modeling (SEM) analysis.

10 **Findings:** Results indicate that KS, AI, and FI have a positive impact on Sustainability of
11 Entrepreneurship, with FI acting as a partial mediator. These findings suggest that leveraging
12 knowledge resources and AI can enhance sustainability through frugal innovation, especially in
13 resource-constrained environments.

14 **Research limitations/implications:** Limitations include a focus on a specific demographic, and
15 future research should explore other industry sectors and external factors like government policies

16 **Practical implications:** This research has implications for prospective entrepreneurs and business
17 actors to be able to develop a culture of sharing knowledge sources and implementing AI to accelerate
18 innovation for sustainability.

19 **Originality/value:** Although significant research has been conducted on sustainable entrepreneurship,
20 studies that comprehensively integrate artificial intelligence, knowledge resources, and frugal innovation
21 are limited. Previous research typically examines the role of each of these variables in more specific
22 contexts. This study seeks to address this gap by developing a more comprehensive model that
23 considers the complex interactions among these factors in driving business sustainability.

24 **Keywords:** Knowledge, Artificial intelligence, Frugal Innovation, Entrepreneurship Sustainability

25 **JEL codes:** L26, M00, M, 54, O10, O30, O32, Q01

26 **1. Introduction**

27 Sustainable development seeks to meet the needs of the present without compromising the ability of
28 future generations to meet their own needs. The government supports green economic growth by
29 prioritizing sustainable natural resource management, environmentally friendly investments, and the
30 responsible use of technology. The effectiveness of these initiatives is evaluated through the Green
31 Economy Index (Gupta & Dharwal, 2022; Coordinating Ministry for Economic Affairs of the Republic
32 of Indonesia, 2023; Neumann, 2022). The government is striving to foster economic growth and
33 innovation by addressing barriers to entrepreneurship. These initiatives also seek to resolve critical
34 societal challenges, including poverty, the prevalence of low-quality jobs in the informal sector, and the
35 digital divide. (Media, 2023; Sony, 2021). Indonesia currently has an entrepreneurship ratio of 3.47%.
36 However, to attain developed nation status by 2045, this ratio needs to rise to 12% of the population.
37 Data from the Central Statistics Agency in 2022 indicates that the youth population in Indonesia is
38 approximately 65.82 million, comprising around 24% of the total population. This demonstrates a
39 substantial potential within the Indonesian population to foster entrepreneurship (Media, 2022, 2023).
40 Entrepreneurship with an environmental focus entails the creation of innovative goods and
41 technologies designed to mitigate environmental issues. This approach underscores the significance of
42 sustainability and actively supports environmental initiatives. Notably, there is a discernible increase in
43 consumer awareness and demand for environmentally conscious products. This necessitates
44 entrepreneurs to assume greater responsibility and recognize the critical importance of conducting
45 business operations in a sustainable manner (Albhirat et al., 2024; M. Gupta & Dharwal, 2022; Ramírez
46 et al., 2019; Zhao et al., 2021). The implementation of sustainable practices within environmentally-
47 focused businesses encounters numerous obstacles. These challenges encompass increased costs and
48 operational timelines, a scarcity of sustainable suppliers, limited supportive policies and regulations,
49 insufficient knowledge and expertise, low levels of participation and support from stakeholders,
50 technological limitations, potential negative impacts on financial performance, and a dearth of mindset
51 shifts and a lack of interest in cultivating entrepreneurial potential within the context of environmental
52 sustainability (Ebolor et al., 2022; Hossain et al., 2023; Kurnia & Priyastiwi, 2024; Pedroso et al., 2023;
53 Zhao et al., 2021). The evolving business landscape has resulted in shorter product life cycles,
54 technological delays, and intensified global competition. Consequently, companies must prioritize
55 several key factors—speed, quality, pricing, innovation, and customer responsiveness—to gain a
56 competitive edge. Specifically, knowledge resources and innovation are considered essential for
57 achieving competitive advantage and long-term success. Within the framework of sustainability,
58 knowledge serves a pivotal role in developing and deploying knowledge resources in a manner that
59 integrates social, environmental, and economic dimensions for sustained success. Aligning knowledge
60 source (KS) strategies with the organization's overarching goals is essential for achieving sustainability
61 across all domains (Arduini et al., 2024; Darroch et al., 2015; Saqib & Satar, 2021; Wijaya & Suasih,
62 2020). There are two primary sources of human knowledge: internal and external. Internal knowledge
63 generation can drive individuals with specific personality traits to be more innovative and achieve
64 success (AlMulhim, 2021; Erjavec et al., 2019; Shaukat et al., 2023). Knowledge plays a significant role
65 in enhancing investment decision-making, particularly among marginalized communities, where greater
66 knowledge leads to improved decisions. While knowledge is a key driver of innovation, its influence,
67 particularly from the perspective of SMEs and emerging markets, remains underexplored (AlMulhim,
68 2021; Kurnia & Priyastiwi, 2024; Lei et al., 2021). In the digital economy, companies encounter both
69 internal and external challenges in maintaining their sustainability within the global market (Anwar,
70 2018; Khraishi et al., 2023; Li et al., 2018). Effectively addressing these multifaceted challenges
71 necessitates technological expertise to develop both short-term and long-term solutions (Duan et al.,

2019). Artificial Intelligence (AI) emerges as one of the most promising solutions, as AI-based communication enables cost-efficient global connectivity and optimized resource utilization (Di Vaio et al., 2020; Wu, 2021). Furthermore, AI and Frugal Innovation (FI) provide data-driven and adaptive solutions to address social challenges (Hossain et al., 2022; Wu, 2021). AI serves as a bridge between artificial technologies and organizational or human knowledge, facilitating smarter, more efficient decision-making processes for managers (Schneider & Leyer, 2019; Sousa & Rocha, 2019). However, AI's primary use remains in data processing, particularly in fields such as education and healthcare, and it is still limited in predictive capabilities (B. B. Gupta et al., 2023; Vecchiarini & Somià, 2023; Wu, 2021). To optimize AI adoption, businesses must address legal, ethical, societal, and educational considerations (Kaplan & Haenlein, 2019, 2020). AI is transforming management practices and enhancing competitiveness by enabling businesses to deliver sustainable products and services (Garbuio & Lin, 2019; Govindan, 2024; Lei et al., 2021; Wright & Schultz, 2018). However, with financial and knowledge constraints, companies are expected to meet customer demands through FI (Hossain, 2021; Hossain et al., 2023). Research indicates that FI contributes to sustainability by addressing global challenges, such as driving economic development, meeting societal needs, and promoting environmental protection (Albert, 2022; Khan & Melkas, 2020). Nevertheless, government policies and knowledge resources supporting FI in developing countries remain insufficient. FI activities are often led by large organizations, while certain societal groups perceive FI as a symbol of low social status (Ebolor et al., 2022; Shahid et al., 2023). A significant challenge in implementing FI lies in managing technology, particularly amidst competitive advancements in AI, which can make access to affordable technology difficult for small businesses and startups. Studies highlight the critical role of AI access in enabling small businesses to innovate effectively. The integration of AI into FI can amplify the efficiency and impact of innovation from multiple perspectives (Govindan, 2024; Thakare et al., 2022). Additionally, millennials are increasingly motivated to invest due to the accessibility of technology-driven information and cost efficiency (Priyastiw, 2023). Combining research on FI, AI, and knowledge resources has the potential to harness emerging technologies for developing sustainable solutions. Despite prior research on entrepreneurship sustainability, there remains a lack of comprehensive models integrating AI, knowledge sources, and FI within the context of SMEs and developing countries. Current studies on AI focus primarily on its applications in data processing, education, and healthcare (B. B. Gupta et al., 2023; Vecchiarini & Somià, 2023), while research on FI often examines its links to economic transformations and environmental concerns (Pedroso et al., 2023; Shahid et al., 2023, 2023). This study applies the Resource-Based View (RBV) and Job Demands-Resources (JDR) theoretical frameworks, utilizing mediation analysis to develop an integrated model for entrepreneurial sustainability. The study aims to achieve three objectives: first, to analyze the impact of knowledge sharing on frugal innovation and its subsequent effect on entrepreneurship sustainability; second, to evaluate the influence of AI on frugal innovation and its role in business sustainability; and third, to investigate the combined effects of knowledge sharing and AI on business sustainability, with frugal innovation acting as a mediating variable.

110 **2. Theoretical Background and Hypotheses Development**

111 **2.1. Theoretical Background**

112 The theoretical approaches used in this research are the Resource-Based View (RBV) and the Job
113 Demands-Resources (JDR) model. RBV focuses on the strategic assets and competencies, emphasizing
114 their financial and economic impacts to identify, utilize, and implement sustainable environmental
115 initiatives for achieving competitive advantage (Barney, 1991). This framework establishes a theoretical
116 foundation for evaluating Frugal Innovation (FI) and Artificial Intelligence (AI) by emphasizing the
117 significance of valuable resources and capabilities in achieving sustainable competitive advantages

118 (Kruesi & Bazelmans, 2023). JDR model identifies two primary categories: job demands and job
119 resources. Job resources encompass physical, psychological, social, and organizational factors that
120 facilitate the attainment of work goals, alleviate physical and psychological strain, and promote
121 individual growth, learning, and development. A key job resource is the ability and capacity to acquire
122 and apply relevant knowledge effectively (Bakker & Demerouti, 2007).

123 RBV theory focuses on the utilization of a company's internal resources that are highly valuable,
124 difficult to obtain, hard to imitate, and irreplaceable as the primary elements for achieving long-term
125 competitive advantage. These resources include physical assets, expertise, and organizational
126 capabilities. Artificial Intelligence (AI) is a technology that allows machines to emulate human cognitive
127 functions, such as learning and decision-making. By analyzing complex data, AI has the potential to
128 improve efficiency, enhance quality, and generate valuable business insights. When integrated within the
129 RBV framework, AI enables businesses to optimize resource management, respond effectively to
130 market dynamics, and achieve enhanced performance outcomes. (D. Chen et al., 2022).

131 The application of AI in business can be examined through the lens of RBV. AI can be regarded as a
132 strategic resource that enhances the ability to manage resources, optimize production, and improve
133 business sustainability. The utilization of AI in business can identify patterns, increase operational
134 efficiency, and better meet market demands, thereby creating a sustainable competitive advantage. The
135 integration of AI into business strategies, guided by the RBV, can help address critical industry
136 challenges, including climate change and the growing demand for more sustainable business practices.
137 RBV and AI are interconnected within the context of digital business strategy, enabling companies to
138 enhance their AI capabilities and achieve sustainable competitive advantage. Implementing AI within
139 the RBV context can improve overall business performance, both economically and socially. AI assists
140 companies in creating economic value through cost reduction and increased revenue, as well as social
141 value through contributions to society. Furthermore, AI enables businesses to quickly adapt and
142 transform resources in response to changing market needs. This aligns with the fundamental principles
143 of RBV, which emphasize the importance of a company's ability to manage and respond to
144 environmental changes (Al-Ramahi et al., 2024; Moderno et al., 2024; Rejeb et al., 2022).

145 The RBV underscores the importance of utilizing unique resources and capabilities to attain a
146 competitive advantage. FI, which emerges from the need to innovate under resource constraints, aligns
147 closely with RBV principles. FI refers to the creation of products, services, or solutions developed
148 despite limitations in financial, human, and technological resources, specifically targeting the needs of
149 consumers with restricted purchasing power. It is defined by three essential criteria: affordability,
150 optimized performance, and functionality adapted to the local context (Hindocha et al., 2021). Three
151 essential capabilities for FI include a focus on core functionality, significant cost reduction, and ongoing
152 engagement with stakeholders. The frugal approach enables companies to create high-quality products
153 and services at low costs, thereby supporting the RBV principle of generating competitive advantage.
154 Furthermore, FI also highlights sustainability and collaboration as strategic resources for enhanced
155 innovation. RBV highlights the importance of sustaining competitive advantage by leveraging unique
156 resources and capabilities. In the context of FI, companies can strategically configure their resources
157 and capabilities in ways that are challenging for competitors to replicate, thereby establishing a
158 sustainable edge in the market. The integration of RBV principles with FI allows companies to
159 formulate sustainable and inclusive strategies that not only address challenges of accessibility and
160 affordability but also contribute to sustainable development goals (Dost & Umrani, 2024; Rossetto et
161 al., 2023). Previous studies have shown slightly different findings, indicating that technological
162 capability is a key factor in attracting business investment. While FI offers unique solutions by
163 providing competitive advantages within the RBV framework, digital technologies such as AI and IoT
164 play a more dominant role in enhancing investment appeal (Diógenes et al., 2024).

165 JD-R framework is utilized to understand how job characteristics influence employee well-being and
166 performance. This model differentiates between "job demands", which may contribute to stress, and
167 "job resources", which provide support to employees in achieving their goals, reducing strain, and
168 fostering growth and development. The relationship between JD-R and AI indicates that AI has a dual
169 impact. On one hand, AI can increase job demands through the anxiety and uncertainty it generates.
170 The JD-R model explains that job demands (such as excessive workload) can affect employee well-
171 being and behavior. High workloads can lead to stress and fatigue, which in turn may diminish
172 employees' ability to engage in effective behaviors. On the other hand, AI can also function as a
173 resource that helps employees cope with these demands and enhance performance. From the
174 perspective of job demands, the use of AI is seen as potentially increasing job demands. This is due to
175 employees' concerns that their positions and jobs may be replaced by technology. Such uncertainty can
176 lead to significant anxiety and stress, burdening employees' psychological and emotional conditions. AI
177 is also perceived to heighten work pressure through more complex tasks, the necessity to understand
178 new technologies, and the potential for excessive monitoring. Conversely, AI can serve as a job
179 resource. AI technology can assist employees in managing their workloads, improving efficiency, and
180 providing support in decision-making. Additionally, it can foster intrinsic motivation by offering
181 opportunities for growth and innovation, particularly in enhancing skills to navigate a technology-
182 driven work environment. AI can enhance work efficiency, provide faster feedback, and expand
183 professional capabilities by automating routine tasks, AI enables employees to concentrate on more
184 strategic and creative responsibilities, enhancing productivity and fostering innovation within the
185 organization (Kim & Kim, 2024; Liang et al., 2022; Qiu et al., 2022).

186 The integration of AI within organizations should not solely focus on productivity enhancement but
187 also contribute to sustainability. To achieve better sustainability, organizations need to adopt a holistic
188 approach to managing automation and AI. AI can aid in better resource management, waste reduction,
189 and the development of more environmentally friendly products. It can support business sustainability
190 goals by creating more efficient processes while simultaneously reducing environmental impact (Gómez
191 Gandía et al., 2025). The JD-R framework indicates that job resources, such as task autonomy,
192 teamwork, and employee engagement, positively contribute to employees' immaterial satisfaction. The
193 application of AI can be seen as a valuable tool for improving the efficiency and effectiveness of
194 Sustainable Human Resource Management (SHRM) practices, enabling organizations to optimize
195 processes and support long-term sustainability goals. AI can assist in managing workloads, improving
196 team collaboration, and facilitating employee engagement in a more structured and responsive manner.
197 Thus, the integration of AI into SHRM practices can support the achievement of organizational
198 sustainability goals by enhancing employee well-being and overall organizational performance. The
199 relationship between JD-R, AI, and sustainability suggests that by leveraging the right resources and
200 innovative technologies, organizations can create a more sustainable work environment, which in turn
201 supports employee performance and satisfaction (Tortia et al., 2022). Previous studies on JD-R theory
202 in relation to FI, AI, and entrepreneurial sustainability remain quite limited; however, there is one
203 relevant study. The findings of this study reveal that an organization's ability to balance the exploration
204 of new opportunities with the utilization of existing resources can support frugal innovation,
205 specifically through approaches that yield low-cost products or solutions with high efficiency. FI
206 reinforces business objectives aimed at reducing waste and repurposing leftover materials, for instance.
207 Furthermore, AI can enhance the effectiveness of FI and support business supply chains through
208 improved data analysis, forecasting, and process optimization (Al-kahtib et al., 2025).

209 **2.2. Hypotheses Development**

210 **2.2.1. Knowledge Source, Frugal Innovation and Sustainability of Entrepreneurship**

211 Entrepreneurs with a deep understanding of market needs can harness their creativity, adaptability, and
212 risk-taking abilities to overcome challenges in resource-constrained environments, developing
213 innovative solutions that meet customer demands despite limited resources (Karyaningsih et al., 2020).
214 The concept of Knowledge Source (KS) stems from knowledge management and is defined as the
215 exchange of experiences, facts, knowledge, and skills throughout an organization, facilitating learning
216 and fostering the sharing of valuable information among individuals and teams (Malik & Kanwal,
217 2018). KS plays a critical role in strengthening business capabilities in today's dynamic economy by
218 fostering creativity and accelerating innovation within organizations (Azeem et al., 2021). KS, in
219 particular, facilitate new business opportunities and empower employees to share information that
220 resolves key challenges by innovating and enhancing workflows (Danish et al., 2014). KS plays a critical
221 role in enhancing an organization's capacity to manage its knowledge resources, thereby empowering
222 individuals to accomplish business goals more efficiently. Moreover, KS is widely acknowledged as a
223 vital organizational asset essential for achieving a competitive edge (Wang & Noe, 2010; Yang et al.,
224 2018). Given the ongoing business transformation and increasing workplace diversity, KS are essential
225 for creating opportunities that enhance employee self-efficacy, support learning, and disseminate
226 knowledge to relevant stakeholders. Furthermore, KS is inherently connected to FI by empowering
227 individuals to recognize opportunities, optimize the use of constrained resources, and create cost-
228 effective, scalable solutions (Karyaningsih et al., 2020).

229 Both internal and external knowledge sources play a crucial role in shaping and driving FI, particularly
230 in the aspects of functionality and cost. This study highlights the necessity for SME managers to
231 enhance their innovation capabilities by leveraging IT resources and knowledge to sustain operations
232 amidst dynamic environmental changes (Shehzad et al., 2023). Further research on the influence of
233 internal and external knowledge sources on FI in small and medium-sized enterprises (SMEs) reveals
234 that internal knowledge, including employees' experience and expertise, along with external knowledge
235 obtained from customers and suppliers, has a positive impact on FI. Moreover, subsequent studies
236 reveal that external knowledge enhances firms' ability to make risky decisions critical for fostering FI
237 (Dost et al., 2019; Dost & Khan, 2021). KS also acts as a bridge between sustainable leadership and FI.
238 The findings highlight the critical role of sustainability-oriented leadership, access to diverse knowledge
239 sources, and the credibility of information in fostering sustainable innovation within SMEs (Ur
240 Rehman et al., 2024). Further research indicates that internal knowledge positively contributes to
241 cultivating an innovative culture, which in turn supports FI. In contrast, while external knowledge does
242 not significantly influence an innovative culture, it still plays a direct role in promoting FI (de, 2024). A
243 review of previous studies examining how SMEs achieve sustainability within the green economy
244 through knowledge and FI indicates that both internal and external knowledge sources positively
245 influence sustainability performance, with external knowledge demonstrating a more substantial impact.
246 FI serves as a mediator between KS and sustainability performance, allowing SMEs to optimize the use
247 of their existing resources more efficiently (J. Chen & Zhang, 2024). Previous studies on KS and FI
248 suggest that future research should examine SMEs in other developing countries and focus on
249 sustainability factors such as environmental considerations, organizational support, and knowledge
250 management in the utilization of IT and frugal innovation. Additionally, future research could expand
251 to explore internal factors potentially affecting frugal innovation. Organizations can apply frugal
252 principles such as cost-effectiveness and simplicity to create innovative products and services for
253 underserved markets (AlMulhim, 2021). Organizations can adopt frugal principles, including cost-
254 effectiveness and simplicity, to develop innovative products and services tailored to the needs of
255 underserved markets (Qin, 2024). Knowledge drives the adaptive development of FI by enabling rapid
256 learning, fostering positive social impacts, and supporting market adoption. When combined with an
257 entrepreneurial mindset, FI often facilitates the creation of sustainable solutions to address a wide range

258 of global challenges. Although several researchers have emphasized the importance of KS in driving
259 overall innovation and improving organizational performance, the focus on the role of KS in Corporate
260 Sustainable Development (CSD) remains limited (Abbas & Sağsan, 2019; Wang & Noe, 2010). Hence,
261 this study employs KS to analyze its influence on FI, hypothesizing:

262 *H1a: Knowledge sources positively influences frugal innovation.*

263 The entrepreneurial ecosystem, which involves companies, universities, customers, and suppliers, can
264 drive innovation and the creation of sustainable solutions. Strong collaboration and interaction among
265 various stakeholders are crucial in developing environmentally friendly products, processes, and
266 business models, while also contributing to the achievement of sustainability goals. Although challenges
267 remain, there is still hope that entrepreneurship can serve as a key to addressing environmental changes
268 (Raposo et al., 2022). Previous studies highlight the significant role of knowledge in enhancing the
269 competitiveness and innovation of small business entrepreneurs through sustainable business models
270 aimed at achieving sustainability and competitive advantage. The research findings suggest that active
271 participation in communities and effective knowledge management can create positive customer
272 experiences, although challenges in transforming knowledge into innovation persist (Dias et al., 2023).
273 While businesses can contribute to sustainable development, particularly in knowledge creation and job
274 generation, the environmental and social impacts of businesses are often overlooked. Thus,
275 entrepreneurship plays a crucial role in driving the transition towards a more sustainable bioeconomy
276 (Sili & Dürr, 2022). Studies on the development of sustainable entrepreneurial ecosystems indicate that
277 the state of the entrepreneurial ecosystem is vital for promoting innovation and sustainability.
278 However, government interventions may hinder outcomes if policies do not focus on customer needs.
279 Additionally, stronger collaboration between academia, industry, and government is necessary to
280 enhance business sophistication and attract more investment. The limitations of the domestic market
281 and complex knowledge transfer policies also pose challenges in enhancing knowledge and technology
282 output in small businesses (Villegas-Mateos, 2022). Research shows that knowledge-driven
283 entrepreneurship can improve local economic resilience and drive social progress. Moreover, policies
284 that support local entrepreneurship and innovation are crucial, as neglecting knowledge means
285 disregarding valuable resources that can help overcome significant challenges in achieving sustainable
286 development goals (Onwuegbuzie et al., 2024). Based on previous studies, the following hypothesis is
287 proposed:

288 *H1b: Knowledge source positively influences the sustainability of entrepreneurship.*

289 **2.2.2. Artificial Intelligence, Frugal Innovation and Sustainability of Entrepreneurship**

290 Complex challenges in the business world necessitate technological expertise to develop both
291 immediate and long-term solutions. One of the most promising options is Artificial Intelligence (AI),
292 where machines have the ability to "learn from experience, adapt to new inputs, and perform tasks
293 similarly to humans," offering innovative solutions to a wide range of problems (Duan et al., 2019;
294 Thakare et al., 2022). AI technology provides three key benefits: First, it automates essential yet
295 repetitive and time-consuming tasks, freeing up human resources to focus on higher-value activities.
296 Second, AI extracts valuable insights from vast amounts of unstructured data that would otherwise
297 require human analysis and management. Third, AI can seamlessly integrate thousands of computers
298 and other resources to address the most complex challenges (Nishant et al., 2020). AI can enhance
299 organizational processes by aligning with individual cultures and practices, thereby reducing the
300 demand for natural resources and energy in human activities. The true value of AI extends beyond its
301 ability to help individuals and societies reduce energy, water, and land use intensity. Its most significant
302 impact will be realized at a higher level, where it facilitates and promotes more effective environmental
303 governance, driving sustainable practices on a broader scale (Govindan, 2024; Thakare et al., 2022).

304 Moreover, AI holds a pivotal role in driving FI by facilitating affordable automation, personalized
305 solutions, advanced data analysis, and more streamlined services. Previous studies have highlighted AI's
306 potential in FI to generate beneficial, adaptive, and data-driven solutions to pressing social challenges.
307 By leveraging AI, frugal innovators can achieve operational efficiency with limited resources while
308 addressing challenges in developing economies, delivering impactful and measurable outcomes.
309 Furthermore, AI serves as a crucial enabler in FI, connecting smart devices and empowering
310 organizations with data-driven insights to create innovative and sustainable solutions (Balogun et al.,
311 2024). FI has empowered businesses to harness the potential of innovative ideas and technologies by
312 emphasizing simplicity, cost-efficiency, and creativity. This concept has gained global recognition,
313 benefiting not only developing countries but also inspiring sustainable solutions worldwide. Over the
314 past few decades, research on FI has progressed to address the challenges faced in resource-constrained
315 environments, particularly in developing economies. However, the integration of AI into FI warrants
316 more attention, as it offers substantial opportunities to enhance the impact and effectiveness of frugal
317 solutions across multiple dimensions (Govindan, 2024; Sarkar & Mateus, 2022).

318 A study highlights the role of AI in supporting SMEs to expand internationally. While AI may not
319 always be a primary requirement, it can enhance frugal innovation and assist SMEs in transforming
320 their business models. The research indicates that by combining FI with AI, SMEs can increase their
321 competitiveness in global markets (Saleem et al., 2024). Other studies have explored the creation of
322 affordable yet high-quality products and services, known as frugal innovation. FI is regarded as a
323 solution to various challenges, particularly for small businesses in developing countries. These studies
324 aim to understand how FI can contribute to achieving Sustainable Development Goals (SDGs),
325 especially in resource-constrained areas. Furthermore, AI has been found to significantly enhance FI,
326 fostering inclusive and sustainable economic growth while minimizing environmental impact
327 (Escudero-Cipriani et al., 2024). Previous research also reveals that companies seeking to leverage AI
328 for cost-efficient innovation must first have a comprehensive understanding of AI and be willing to
329 invest in this technology. Factors such as communication and government support are shown to play a
330 limited role in business expansion, particularly after significant disruptions in the business environment.
331 Findings further discuss the development of simple, affordable, and effective products and services
332 under the concept of FI. Technologies like the Internet of Things (IoT) and AI have been identified as
333 key drivers of FI, particularly in countries such as China. Additionally, research indicates that businesses
334 with entrepreneurial knowledge are more likely to effectively leverage the Internet of Things (IoT) and
335 AI to drive the development of FI (Govindan, 2024; Qin, 2024). Based on these studies, the proposed
336 hypothesis is:

337 *H2a: AI positively influences of frugal innovation.*

338 AI plays a crucial role in promoting business sustainability and addressing environmental challenges,
339 particularly in the fight against climate change. It can also enhance the efficient use of natural resources
340 and energy. For instance, AI can optimize energy consumption in homes or factories, improving
341 efficiency, and automate various tasks to reduce waste and resource usage. However, several challenges
342 must be addressed, such as ensuring that the data used by AI is accurate and reliable, and understanding
343 how human behavior interacts with AI. Moreover, it is crucial to consider the long-term sustainability
344 of AI usage, beyond just short-term benefits (Nishant et al., 2020). Additional studies highlight that AI-
345 driven innovation is a critical element of entrepreneurship, linking various topics and goals of
346 Sustainable Development (SDGs). AI has the potential to enhance efficiency and effectiveness across
347 sectors such as healthcare, agriculture, and resource management by offering innovative solutions to
348 environmental and social challenges. However, issues like ethics, inequality, and the environmental
349 impact of AI adoption continue to pose significant challenges (Năstasă et al., 2024; Reyes-Menendez et
350 al., 2023). AI can also enhance understanding of environmental changes, such as climate patterns, and

351 contribute to more effective solutions to address climate crises. Yet, the development of AI brings with
352 it certain drawbacks, such as potential increases in greenhouse gas emissions, making responsive
353 governance essential to harness its benefits responsibly (Cowls et al., 2023). Other research emphasizes
354 the importance of managers and policymakers in formulating strategies to achieve sustainable
355 development goals in the digital era through the appropriate utilization of AI (Bag et al., 2021).
356 Elements such as new ideas, business decisions, and resources are interconnected within the digital
357 ecosystem. Digital platforms like AI, the internet, and applications play a vital role in connecting
358 entrepreneurs, facilitating collaboration, fostering the creation of new and improved business models,
359 and promoting sustainability (Elia et al., 2020). Previous studies suggest a need for further research into
360 the integration of AI with other factors, such as knowledge, to achieve sustainability, particularly within
361 small businesses. Thus, the proposed hypothesis is:

362 *H2b: AI positively influences sustainability of entrepreneurship.*

363 **2.2.3. The Mediating Role of Frugal Innovation**

364 Furthermore, research on the relationship between KS, FI, and sustainability entrepreneurship is still
365 scarce. Previous studies suggest that organizations rooted in knowledge-based operations are not only
366 more innovative but are also better positioned to explore new opportunities for sustainability (Abbas &
367 Sağsan, 2019). Dynamic organizations harness technology to develop new products or improve existing
368 ones and processes, thereby enhancing organizational performance from economic, environmental, and
369 social perspectives (Anwar, 2018). While previous studies have shown that FI can be a solution to
370 sustainability problems, its scope is still limited. The use of appropriate technology and FI is crucial for
371 achieving sustainable development. Entrepreneurs with broad knowledge in various fields can create
372 innovative and cost-effective products to address environmental challenges. Additionally, effective
373 knowledge management and the ability to adapt to changing technology also play a significant role in
374 driving cost-effective innovation (Bazyar et al., 2024; Rao & Liefner, 2023; Régnier, 2023). To address
375 this gap, the present study examines the relationship between KS, FI, and sustainability
376 entrepreneurship. The hypotheses are stated as follows:

377 *H3a: FI positively influences sustainability of entrepreneurship.*

378 *H3b: Frugal innovation mediates the influence of knowledge source and artificial intelligence on sustainability of*
379 *entrepreneurship.*

380

381 **3. Data and Methods**

382 **3.1. Research Design**

383 This study utilizes a quantitative cross-sectional approach, collecting data from a group of individuals or
384 respondents at a specific point in time within one year. The methods employed are descriptive and
385 correlational. The descriptive method begins by formulating research problems to explore or describe
386 the social situation being studied comprehensively. It aims to provide a clear picture of the observed
387 phenomena without manipulating or influencing variables. Meanwhile, the correlational method
388 measures the degree to which variations in one factor relate to variations in another, using correlation
389 coefficients as a measurement tool (Bougie & Sekaran, 2020).

390 **3.2. Data Source**

391 The data used includes primary data, directly collected from original sources to answer research
392 questions. This data is gathered through interviews, surveys, or observations. In addition, secondary
393 data, which is indirectly obtained from other sources, serves as supplementary information to fulfill
394 data needs in this research (Bougie & Sekaran, 2020).

395 **3.3. Population, Sample, and Sampling Technique**

396 The population targeted in this study consists of all students enrolled in Higher Education (HE). The
397 sample was drawn from students residing in various provinces across five major islands in Indonesia. A
398 non-probability sampling method, specifically incidental sampling, was employed. This approach selects
399 participants based on their availability and accessibility, without relying on measurable probabilities
400 (Bougie & Sekaran, 2020). The use of this method was necessitated by the challenges in accessing the
401 entire target population. By focusing on the population across five major islands in Indonesia, the study
402 aimed to ensure that the sample reflects diverse demographic and socioeconomic characteristics. To
403 minimize potential bias, respondents were assured that their responses would remain confidential. The
404 demographic attributes considered in the study include factors such as age, gender, ethnicity, education,
405 occupation, and income. Given the dispersed nature of the target population, non-probability incidental
406 sampling was deemed a practical and effective approach to collecting data from available and willing
407 participants. The total sample size utilized in this study consists of 314 respondents.

408 **3.4. Data Collection Techniques**

409 Data was collected through interviews and distributing questionnaires to respondents. The
410 questionnaire includes general respondent information and statements related to the research variables.
411 The statements were measured using a 5-point Likert scale.

412 **3.5. Research Variables**

413 The independent variables in this study are knowledge sources, measured by 10 adapted items (Shahid
414 et al., 2023). AI measured by 7 adapted items (Qin, 2024). The dependent variable is interest in
415 entrepreneurship, measured by 8 adapted items (Alvarez-Risco et al., 2021). The mediating variable FI,
416 is measured by 5 adapted items (Al-Omouh et al., 2024).

417 **3.6. Data Analysis**

418 The data analysis process is essential to ensure that the collected data, from both fieldwork and other
419 sources, can be systematically analyzed and used to support research findings or informed decision-
420 making. The data was tested and analyzed using Structural Equation Models (SEM) processed through
421 Smart Partial Least Squares (SmartPLS) software. The steps for SEM-PLS testing are as follows:

422 **3.6.1. Outer Model Analysis**

423 The measurement of the outer model aims to assess the validity and reliability of the variables. This
424 includes convergent validity, where the loading factor value between latent variables and their indicators
425 should be above 0.6. Additionally, composite reliability is used to evaluate construct reliability, with a
426 value greater than 0.6 indicating high reliability. Finally, the Average Variance Extracted (AVE) should
427 have a minimum value of 0.5, reflecting how effectively the construct is measured by its indicators
428 (Hair et al., 2019, 2021).

429 **3.6.2. Inner Model Analysis**

430 The measurement of the inner model is used to test the relationships between latent constructs,
431 including R-Square and Q-Square. R-Square represents the coefficient of determination for endogenous
432 constructs, with values classified as substantial (0.67), moderate (0.33), or weak (0.19). Prediction
433 relevance (Q-Square) evaluates how well the model predicts outcomes, with categories of small (0.02),
434 moderate (0.15), and large (0.35). This test is applicable only to endogenous constructs with reflective
435 indicators (Hair et al., 2019, 2021).

436 3.6.3. Hypothesis Testing.

437 Hypothesis testing is performed by examining the t-statistic and probability values (p-values). For a 5%
438 alpha level, the critical t-statistic is 1.96 (Hair et al., 2021).

439 4. Results and Discussion

440 4.1. Result

441 4.1.1. Respondent Characteristics

442 A total of 314 respondents will be included in this research. The characteristics of the respondents are
443 divided by gender, with 67.8% female and 32.2% male. Most respondents are between the ages of 20
444 and 25 (75.5%). Another characteristic is the respondents' monthly income, where 54.8% earn less than
445 IDR 1.000.000 per month. Lastly, based on entrepreneurial experience, 54.5% of the respondents have
446 had experience owning or running a business (Table 1. Respondent Characteristics).

Characteristics		Amount	Percentage
Gender	Women	213	67.8
	Man	101	32.2
Age	< 20 years	67	21.3
	20 - 25 years	237	75.5
	26 - 30 years	3	1
	31 - 35 years	2	0.6
	> 35 years	5	1.8
Monthly income	< 1.000.000	172	54.8
	1.000.000 - 2.000.000	105	33.4
	2.000.000 - 3.000.000	27	8.6
	3.000.000 - 4. 000.000	5	1.6
	> 5.000.000	5	1.6
Have a business/Have run a business	Yes	171	54.5
	No	143	45.5
Total		314	100

447 Table 1. Respondent Characteristics

448 4.1.2. Evaluation of the Measurement Model (Outer Model)

449 The validity of the model is assessed by examining the loading factor or outer loading. An indicator is
450 considered valid if the loading factor exceeds 0.6. Based on the analysis results, invalid indicators, such
451 as some items under the KS and AI variables, were removed due to having a loading factor below 0.6.
452 After removing these invalid indicators, the final results showed that all remaining items met the
453 validity criteria with loading factor values above 0.6 (Figure 1. Results of Outer Model Testing and
454 Tabel 2. Loading Factor Value).

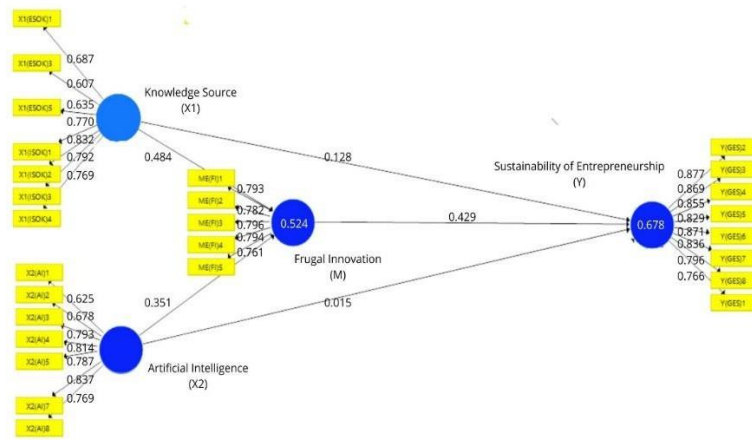


Figure 1. Results of Outer Model Testing

Item	KS	AI	FI	Sustainability
X1(ESOK)1	0.687			
X1(ESOK)3	0.607			
X1(ESOK)5	0.635			
X1(ISOK)1	0.770			
X1(ISOK)2	0.832			
X1(ISOK)3	0.792			
X1(ISOK)4	0.769			
X2 (AI)1		0.625		
X2 (AI)2		0.678		
X2 (AI)3		0.793		
X2 (AI)4		0.814		
X2 (AI)5		0.787		
X2 (AI)7		0.837		
X2 (AI)8		0.796		
ME(FI)1			0.793	
ME(FI)2			0.782	
ME(FI)3			0.796	
ME(FI)4			0.794	
ME(FI)5			0.761	
Y(SE)1				0.877
Y(SE)2				0.896
Y(SE)3				0.855
Y(SE)4				0.829
Y(SE)5				0.871
Y(SE)6				0.836
Y(SE)7				0.796
Y(SE)8				0.766

Tabel 2. Loading Factor Value

455

456

457

458 The reliability of the variables was tested using Composite Reliability (CR), which must exceed 0.7, and
 459 Average Variance Extracted (AVE), which must be greater than 0.5. The analysis results showed that all
 460 research variables, including independent, mediating, and moderating variables, had CR values above
 461 0.7 and AVE values above 0.5. This indicates that the measurements for each variable are reliable and
 462 demonstrate good reliability (Table 2. CR and AVE Result).

Variable	CR	AVE
AI	0.905	0.579
Sustainability	0.950	0.703
FI	0.889	0.617
PT → KS	1.000	1.000
PT → AI	1.000	1.000
PT	0.931	0.512
PT → FI	1.000	1.000
KS	0.889	0.535

463 Table 3. CR and AVE Result

464 **4.1.3. Evaluation of the Structural Model (Inner Model)**

465 The R² value indicates how much of the variation in the dependent variable can be explained by the
 466 independent variables. Based on the analysis, the model shows an R² value of 0.67, meaning that
 467 variables such as SoK, AI, and FI explain 67% of the variation in GES, which is considered a strong
 468 effect. Q² is used to measure the predictive ability of the model. Q² value greater than 0 indicates that
 469 the variables and data can predict the model well. The obtained Q² value of 0.47 demonstrates that the
 470 model has good predictive relevance (Table 3. R² and Q² Test Results).

Variable	R ²	Q ²
GES	0.670	0.470
FI	0.521	0.312

471 Table 4. R² and Q² Test Results

472 The subsequent step entails conducting hypothesis testing to assess the influence of independent
 473 variables on the dependent variable. This process aims to ascertain whether a statistically significant
 474 relationship exists between the two variables. The findings from the statistical analysis, which include
 475 direct and indirect effects, total effects, p-values, and test statistics, are presented in Table 5. These
 476 findings provide a clear overview of the validity of the proposed hypotheses. The direct effect refers to
 477 the immediate impact of one variable on another without the involvement of mediating variables; for
 478 example, the direct effect of Artificial Intelligence (X2) on Sustainability Entrepreneurship (Y) is 0.165,
 479 indicating a significant direct relationship. In contrast, the indirect effect represents the influence of one
 480 variable on another through intervening variables, as illustrated by the indirect effect of Artificial
 481 Intelligence (X2) on Sustainability Entrepreneurship (Y) through Frugal Innovation, calculated as X2
 482 → FI (0.351) * FI → Y (0.429) = 0.151. The total effect, which reflects the overall impact of one
 483 variable on another, is the sum of the direct and indirect effects; in this case, the total effect of Artificial
 484 Intelligence (X2) on Sustainability Entrepreneurship (Y) is 0.165 (direct effect) + 0.151 (indirect effect)
 485 = 0.316. Finally, the path coefficient, representing the standardized regression coefficient, reflects the
 486 strength and direction of the relationships between variables, with higher values signifying stronger
 487 associations. Mediation takes place when the effect of an independent variable on a dependent variable

488 is channeled through a mediator variable. In this context, mediation analysis helps to determine
 489 whether the relationships between variables such as Knowledge Source (X1), Artificial Intelligence
 490 (X2), and Sustainability Entrepreneurship (Y) are direct or mediated by another variable, such as Frugal
 491 Innovation. The results indicate that the mediating variable, Frugal Innovation, significantly mediates
 492 the effects of both Knowledge Source and Artificial Intelligence on Sustainability Entrepreneurship.

Pathway	Direct Effect	Indirect Effect	Total Effect	Path Coefficient	t-statistic	p-value	Conclusion
Knowledge Source (X1) → Frugal Innovation	0.484	-	0.484	0.484	9.230	0.000	Hypothesis 1a supported
Knowledge Source (X1) → Sustainability Entrepreneurship (Y)	0.336	0.208	0.544	0.339	5.592	0.000	Hypothesis 1b supported
Artificial Intelligence (X2) → Frugal Innovation	0.351	-	0.351	0.349	7.966	0.000	Hypothesis 2a supported
Artificial Intelligence (X2) → Sustainability Entrepreneurship (Y)	0.165	0.151	0.316	0.166	3.538	0.000	Hypothesis 2b supported
Frugal Innovation → Sustainability Entrepreneurship (Y)	0.429	-	0.429	0.430	7.901	0.000	Hypothesis 3a supported
Knowledge Source (X1) → Frugal Innovation → Sustainability Entrepreneurship (Y)	-	0.484 * 0.429 = 0.208	-	0.208	5.734	0.000	Hypothesis 3b supported
Artificial Intelligence (X2) → Frugal Innovation → Sustainability Entrepreneurship (Y)	-	0.351 * 0.429 = 0.151	-	0.151	5.369	0.000	

495 The research findings validate the first hypothesis, demonstrating that knowledge sources have a
496 significant and positive effect on innovation. This suggests that an increase in knowledge leads to
497 higher levels of innovation, allowing companies to create new solutions and enhance their internal
498 processes. Additionally, the study provides evidence that a strong knowledge culture within an
499 organization is a critical driver of innovation. The results indicate that when employees actively share
500 their ideas, experiences, and knowledge, it generates a unique synergy. This synergy stimulates the
501 development of new creative ideas, innovative solutions to problems, and the creation of improved
502 products or services. In essence, the greater the sharing of knowledge sources, the richer the
503 organization's "pool of ideas," thereby enhancing the likelihood of fostering innovation. This research
504 underscores the importance of cultivating a dynamic learning community within organizations. When
505 employees feel supported and encouraged to share their knowledge, it not only boosts individual
506 performance but also nurtures innovation, which can serve as a competitive advantage. Successful
507 organizations are those that effectively harness their intellectual potential. By facilitating knowledge
508 sharing and its resources, they can also create a more innovative and adaptable work environment that
509 responds effectively to change. Furthermore, by facilitating the exchange of knowledge and resources
510 on green technology, environmental regulations, and industry best practices, organizations can
511 accelerate the transition toward more sustainable business models. Additionally, sharing knowledge
512 resources can help identify new business opportunities related to sustainability, such as the
513 development of eco-friendly products or sustainability consulting services. Innovation, particularly in
514 the areas of products and processes, acts as a catalyst for adopting environmentally friendly practices.
515 Innovative companies tend to develop more efficient products and services that have a lower carbon
516 footprint. Furthermore, innovation in production processes enables companies to optimize the use of
517 natural resources, reduce waste, and enhance operational efficiency. Innovation not only drives
518 business growth but also serves as a powerful tool for achieving sustainability goals. As a key driver of
519 sustainability, innovation allows companies to create more sustainable products and services, thereby
520 reducing their negative environmental impact while meeting the increasing demands of environmentally
521 conscious consumers. Additionally, innovation can foster the creation of new markets and open up
522 more sustainable business opportunities. In a broader context, sustainability-oriented innovation can
523 contribute to sustainable development and societal well-being. Moreover, investing in R&D becomes
524 essential as companies need to develop new technologies, alternative raw materials, and more
525 environmentally friendly product designs. Thus, innovation is not merely a result of creative processes
526 but also a product of systematic efforts to find more sustainable solutions. Companies committed to
527 sustainability must allocate adequate resources to R&D activities to promote ongoing innovation. The
528 findings of this study are consistent with the RBV and JDR theories, both of which underscore the
529 significance of knowledge and its resources as essential elements in task performance, ultimately driving
530 innovation. These results further align with previous research that emphasizes the critical role of
531 knowledge in promoting innovation and sustainability (Azeem et al., 2021; Karyaningsih et al., 2020;
532 Qin, 2024; Thakare et al., 2022; Yang et al., 2018).

533 The findings of this study supporting the second hypothesis, clearly demonstrate that AI has become a
534 major catalyst in driving innovation across various industrial sectors. With its ability to automate
535 repetitive tasks and analyze data on a large scale, AI enables human resources to concentrate on more
536 creative and strategic tasks. In addition to improving operational efficiency, AI-driven business process
537 automation also produces valuable data, which can be utilized to uncover new opportunities for
538 innovation. This enables companies to develop products and services that are better tailored to
539 customer needs while shortening product development cycles. The results of this research confirm that
540 AI plays a central role in driving product and service innovation. Advanced machine learning

541 algorithms allow companies to analyze customer preferences in greater depth, enabling them to create
542 more personalized and relevant products and services. Additionally, AI can be utilized to design new,
543 more complex, and innovative products, such as autonomous vehicles or virtual assistants. Thus, AI
544 not only improves efficiency but also opens up new market opportunities and drives business growth.
545 The research findings indicate that AI's predictive analysis capabilities are key to fostering innovation.
546 By predicting market trends, consumer behavior, and potential risks, companies can make better and
547 more proactive business decisions. AI-supported predictive analysis also enables companies to identify
548 previously untapped innovation opportunities. This allows organizations to develop products and
549 services that not only meet current market needs but also anticipate future demands. AI has paved new
550 avenues for companies to optimize the management of natural resources. With its capability to analyze
551 data on a large scale, AI can identify patterns of energy and raw material consumption that are
552 inefficient. This enables companies to implement more targeted conservation measures. For instance,
553 AI can be utilized to optimize equipment maintenance schedules, reducing downtime and minimizing
554 energy waste. Additionally, AI can assist in managing supply chains more efficiently, thereby reducing
555 travel distances and the carbon emissions associated with transportation. AI has emerged as a driving
556 force in the creation of more environmentally sustainable products and services, while also enabling the
557 design of more efficient and durable items. It can assist in identifying alternative raw materials that are
558 more sustainable and optimizing product designs to reduce waste, offering innovative solutions to
559 complex environmental challenges, such as water pollution. Additionally, AI can forecast equipment
560 failures before they happen, helping to minimize downtime and reduce environmental impacts.
561 Moreover, AI can monitor air and water quality in real-time, allowing companies to take preventive
562 measures before significant environmental damage occurs. In this regard, AI plays a crucial role in
563 helping companies achieve their sustainability objectives. The findings of this study support previous
564 research that has stated that the utilization of AI plays a crucial role not only in specific fields but also
565 in broader areas, including business management (Duan et al., 2019; Govindan, 2024; Hossain et al.,
566 2023; Nishant et al., 2020).

567 AI and FI serve as key drivers of progress in developing economies, fostering economic growth,
568 enhancing productivity, and promoting sustainable development. AI offers powerful tools for efficient
569 data processing, decision-making, and automation, which significantly enhance critical sectors such as
570 healthcare, agriculture, and education. FI, in turn, focuses on designing cost-effective and resource-
571 efficient solutions tailored to the unique needs of low-income communities, fostering inclusivity and
572 addressing localized challenges. The synergy between AI and FI amplifies their impact by enabling the
573 development of scalable, impactful products and services even with limited resources. For example, AI
574 can optimize processes in healthcare and agriculture, improving access to essential services and
575 boosting productivity. Furthermore, this integration helps bridge infrastructure gaps, drives economic
576 growth, and supports the achievement of sustainable development goals. Research underscores the
577 transformative potential of AI-powered frugal solutions in improving living standards, positioning them
578 as essential for the future development of emerging regions. The discussion on the role of AI and
579 frugal innovation in developing economies aligns with prior studies that highlight the benefits of AI in
580 advancing the Sustainable Development Goals (SDGs) (Cowls et al., 2023; Escudero-Cipriani et al.,
581 2024; Qin, 2024; Reyes-Menendez et al., 2023).

582 The results of this study indicate that FI plays a crucial role as a mediator between KS and AI in driving
583 sustainability of entrepreneurship. These findings support our third hypothesis that FI acts as a partial
584 mediator in this relationship. This means that FI is not only influenced by KS and AI but also actively
585 contributes to enhancing sustainability of entrepreneurship. In other words, while KS and AI have a
586 direct impact on sustainability of entrepreneurship, their influence is strengthened when companies
587 adopt FI. This suggests that FI can maximize the benefits of KS and AI technology in achieving

588 sustainability goals. The results also highlight the significant advantages of FI, such as helping
589 companies translate knowledge acquired from various sources, including scientific research and
590 industry best practices, into innovative solutions that are suitable for local contexts and constrained
591 resources. FI enables companies to optimize their use of AI technology more effectively by focusing on
592 simple, cost-effective, and sustainable solutions. FI facilitates the integration of technological
593 innovation with daily business practices, thereby creating sustainable added value.

594 FI serves a key mediating role in the connection between AI and the sustainability of entrepreneurship,
595 enabling businesses to utilize AI technologies in a cost-effective, resource-efficient, and sustainable way.
596 This approach prioritizes simplicity and affordability, empowering entrepreneurs to create solutions
597 that tackle environmental challenges while ensuring economic feasibility. By integrating AI into frugal
598 innovation strategies, entrepreneurs can optimize processes, reduce waste, and enhance decision-
599 making, ultimately contributing to the achievement of sustainable development goals. FI also facilitates
600 the adoption of AI in emerging markets, where resource constraints are prevalent, promoting
601 inclusivity and sustainability. Characterized by its focus on cost-effectiveness, simplicity, and
602 accessibility, FI ensures that AI-driven initiatives are affordable and effective, empowering
603 entrepreneurs to overcome financial and infrastructural barriers. This is particularly significant in
604 developing economies, where limited resources necessitate innovative solutions tailored to specific
605 cultural and economic contexts. By bridging the gap between advanced AI technologies and sustainable
606 entrepreneurial practices, FI enhances operational efficiency and drives significant social and
607 environmental impact. For instance, AI applications in agriculture, enabled by FI, can improve crop
608 yields and promote sustainable farming practices, while AI in healthcare can enhance service delivery
609 and expand access to underserved populations. These outcomes demonstrate how FI enables AI to
610 contribute positively to economic, social, and environmental goals. Furthermore, frugal innovation
611 fosters the development of localized solutions that meet the needs of low-income consumers and
612 encourage inclusive growth. By promoting resilience and adaptability within entrepreneurial ecosystems,
613 it ensures that technological advancements not only enhance the sustainability of individual ventures
614 but also drive broader progress toward sustainable development. This synergy between AI and FI is a
615 vital area of study for understanding how modern entrepreneurship can align technological innovation
616 with global sustainability objectives. The important role of FI mediation is in line with several previous
617 studies (Bazyar et al., 2024; Iqbal et al., 2021; Rossetto et al., 2023).

618 **5. Conclusions**

619 This study shows that KS, AI, and FI positively impact the sustainability of entrepreneurship. KS and
620 AI promote innovation, which, in turn, boosts entrepreneurial sustainability. Furthermore, FI is
621 identified as a partial mediator that amplifies the effect of KS and AI on entrepreneurial sustainability,
622 highlighting the important role of cost-effective innovation in fostering sustainable entrepreneurial
623 practices.

624 The practical implications of this research are to foster innovation and sustainability, companies should
625 cultivate a knowledge-sharing culture and implement effective knowledge management systems.
626 Encouraging collaboration and information exchange enriches the organization's idea pool and drives
627 innovative solutions. The adoption of AI can accelerate innovation by improving operational efficiency
628 and enabling the creation of products and services that better meet customer and market needs. FI
629 should be a core strategy for achieving business sustainability, especially for resource-constrained
630 companies. FI allows organizations to optimize technologies like AI with simple yet effective
631 approaches.

632 The broader implications for theory development in sustainability, innovation, and entrepreneurship
633 are indeed profound and multi-faceted, necessitating a paradigm shift in how economic growth and

634 environmental stewardship are conceptualized. This intersection challenges traditional business models
635 by integrating sustainable practices into the very core of entrepreneurial ventures, thus fostering a form
636 of innovation that not only addresses ecological concerns but also enhances competitive advantage.
637 Theories in this domain must evolve to encompass a holistic view that recognizes the interdependence
638 of social, economic, and environmental factors, thereby promoting a systems-thinking approach. This
639 evolution encourages entrepreneurs to adopt innovative solutions that align with sustainability
640 objectives, ultimately creating value beyond simple profit maximization. Moreover, the development of
641 such theories can assist policymakers in designing regulations that promote sustainable practices,
642 thereby reinforcing entrepreneurship's role as a driver of positive change. These theories must address
643 how businesses can balance profitability with sustainability, ensuring efficient resource use and
644 environmental responsibility. For instance, embracing circular economy principles—where waste is
645 minimized, and materials are reused or recycled—can be a key element of sustainable business models.
646 Furthermore, exploring the integration of AI and other advanced technologies can optimize operations
647 and reduce environmental impacts. The implications of these theories extend beyond individual
648 enterprises, influencing broader societal norms and expectations regarding responsible business
649 conduct, which is essential for achieving long-term sustainability in an increasingly resource-constrained
650 world. This broader perspective necessitates a shift in educational paradigms as well, preparing future
651 leaders to think critically about sustainability and innovation. Integrating these concepts into business
652 education and training can empower the next generation of entrepreneurs to develop solutions that are
653 not only innovative but also sustainable. Thus, the theoretical advancements in this field hold
654 significant promise for shaping a more sustainable and equitable future.

655 This research also makes a theoretical contribution by reinforcing the RBV and JDR theories. These
656 frameworks emphasize the significance of resources, particularly knowledge and innovation, in
657 enhancing organizational performance and sustainability. The findings further enrich the literature on
658 the role of FI in entrepreneurial sustainability and highlight the importance of AI as a key driver of
659 innovation across different sectors. One limitation of this study is that it does not focus on a specific
660 industry sector, meaning the findings may not be entirely applicable to sectors with differing levels of
661 technology adoption or innovation. Additionally, the study does not account for external factors, such
662 as government regulations or market access, which may also influence entrepreneurial sustainability.
663 Future research could explore the impact of KS, AI, and FI across various sectors to assess whether the
664 findings hold consistently. Moreover, future studies should consider external factors like environmental
665 policies or government incentives that could encourage the adoption of sustainable practices.

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959 **THE ANSWER LETTER**

960 Editorial Team

961 Intangible Capital

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963 Dear Editors,

964 Thank you for your constructive feedback on our manuscript entitled “ENVIRONMENTAL
965 ENTREPRENEURSHIP SUSTAINABILITY: EXPLORING ARTIFICIAL INTELLIGENCE,
966 KNOWLEDGE AND FRUGAL INNOVATION.” We appreciate the opportunity to revise our work
967 and address the points raised in your letter. Below, we outline how we have addressed each of your
968 comments:

- 969 1. Theoretical discussion: We have expanded the theoretical framework section to provide a more
970 in-depth discussion of the resource-based view (RBV) and job demands-resources (JDR)
971 models. We have clarified how these theories specifically relate to artificial intelligence (AI),
972 frugal innovation (FI), and entrepreneurial sustainability, highlighting their relevance in our
973 research context.
- 974 2. Research questions and hypotheses: We have revised the presentation of our research questions
975 and hypotheses for greater clarity and coherence. Each hypothesis is now explicitly linked to the
976 theoretical framework, ensuring a more focused and structured presentation.
- 977 3. Sampling method justification: We have included a detailed justification for our choice of non-
978 probability incidental sampling. We explain its appropriateness for our research context and
979 have added information regarding the data collection process, including potential biases and
980 how we mitigated them.
- 981 4. Statistical results presentation: The results section has been revised to provide clearer
982 explanations of our key findings, particularly concerning the structural equation modeling (SEM)
983 analysis. We have elaborated on the mediation analyses, especially the mediating role of frugal
984 innovation.
- 985 5. Practical and theoretical implications: We have expanded our discussion on the practical and
986 theoretical implications of our findings. We now provide a more comprehensive analysis of
987 how our results contribute to theory development in sustainability, innovation, and
988 entrepreneurship, in addition to their relevance for practitioners.
- 989 6. Literature review enhancement: We have enriched the literature review by incorporating more
990 recent studies, particularly those focusing on the role of AI and frugal innovation in developing
991 economies. This enhancement ensures that our review reflects the latest research and
992 strengthens our manuscript's contribution.
- 993 7. Language clarity and academic style: We have carefully revised the manuscript for language
994 clarity and academic style. We have simplified complex sentence structures and clarified vague
995 wording to improve the overall readability and impact of the paper.

996 We believe that these revisions have significantly improved the manuscript, and we are grateful for your
997 guidance in this process. We have attached the revised manuscript along with this response letter,

998 addressing each point raised in your review.

999 Thank you for considering our revised submission. We look forward to your feedback and hope for the
1000 opportunity to proceed to peer review.

1001 Sincerely,

1002 Research team

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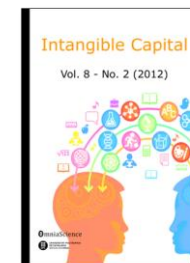
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berdasarkan Surat Keputusan Nomor 3293/M/06/2024 dan Perjanjian / Kontrak Nomor 0609.29/LL5-INT/AL.04/2024 mendapatkan Anggaran Penelitian Keberlanjutan Wirausaha berbasis Lingkungan: Peran Artificial Intelligence, Sumber Pengetahuan dan Frugal Innovation, Sebesar Rp.101.980.000

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